INVESTIGATION AND CHARACTERIZATION OF AIR POLLUTION CONCENTRATIONS AND GRADIENTS IN PORT-ADJACENT COMMUNITIES AND WEST AND DOWNTOWN LOS ANGELES USING A MOBILE PLATFORM

Final Report

Prepared for the California Air Resources Board
Contract No. 04-348

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May 10, 2010

DISCLAIMER

ACKKNOWLEGEMENTS

The contributions of the California Air Resources Board staff, particularly Jorn Herner who made valuable suggestions, Ying-Kuang Hsu our able Project Officer, and Bart Croes, Chief of the Research Division, were greatly appreciated.

We wish to acknowledge valuable contributions from Joe Cassmassi and Kelvin Durkee of the SCAQMD for their technical support. We also wish to thank Dr. Richard Turco at UCLA and Dr. Jun Wu at UC, Irvine, Maria Dacanay at The City of Santa Monica, and Dr. Rod Merl and Mr. Stelios Makrides at Santa Monica Airport for their contributions to this research, and Dr. P.M. Fine of the South Coast Air Quality Management District for sharing his unpublished results. We especially appreciated Albert Chung, Hwajin Kim, Daniel Curtis and Shahir Masri at UCLA, for their assistance in operating the mobile platform, and James Murakami at UCLA for his discussions regarding the sources of meteorological data and the interpretation.

Our time-location study would not have been possible without the community participants who generously welcomed us into their homes and allowed us to track their activities for multiple days. The authors are grateful to the staff and volunteers of the Long Beach Alliance for Children with Asthma and other community and educational organizations which helped pilot data collection methods, provided valuable input, and helped assist in the advertisement of the study and the recruitment of participants. We greatly appreciate Dr. William Hinds of UCLA who loaned the study a condensation particle counter (CPC) instrument and Denis Fitz of UC Riverside who loaned the study two DustTrak instruments. We are grateful to Walberto Martin, Jordan Simms and Carrie Ashendel for their assistance in conducting fieldwork and classifying GPS data, Deborah Estrin, Jeff Burke, Eric Howard, Mohammed Rahimi, Min Mun, Sasank Reddy, and Betta Dawson with the UCLA Center for Embedded Network Sensing for providing GPS equipment and input on GPS classification methods, Dr. Jun Wu of UC Irvine and Dr. Paul Ong and Andrew Mondschein of UCLA for providing helpful input on the study design and methods, and the UCLA Lewis Center for Regional Policy Studies and Director J.R. DeShazo for providing office space and grant assistance. Dr. Arthur Winer thanks the UCLA Luskin Center for Innovation for support as a Luskin Scholar.

We gratefully acknowledge support of this research by the California Air Resources Board. This report was submitted in partial fulfillment of ARB Contract No. 04-348, “Investigation and Characterization of Pollution Concentration Gradients in Wilmington, CA Using a Mobile Platform”, by the University of California, Los Angeles, School of Public Health, Environmental Health Sciences Department. Work was completed as of May 10, 2010.

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ABSTRACT

Real-time measurements with high spatial resolution were conducted using a pollution-free mobile monitoring platform (MP)—an electric vehicle equipped with fast-response instruments for particles and gases—on routes in the South Coast Air Basin. A series of novel findings resulted from our studies in West Los Angeles and Downtown Los Angeles, including Boyle Heights, and in communities adjacent to the Ports of Long Beach and Los Angeles in connection with the ARB-sponsored Harbor Communities Monitoring Study (HCMS).

We discovered that in the pre-sunrise hours, the impacts of vehicle emissions from a major freeway, including ultrafine particles (UFP), extended approximately a factor of ten further (~3000 m vs ~300 m) than during the day. UFP and NO concentrations were strongly correlated with traffic counts on the freeway during this period, but differences in mixing cause pollutant concentrations during pre-sunrise hours to be greater than during morning and afternoon hours, despite much higher traffic counts at those times. We associate the elevated pre-sunrise concentrations over a wide area with a nocturnal surface temperature inversion and low wind speeds, and believe this discovery has important exposure assessment implications.

MP measurements in Wilmington and Long Beach showed diesel truck-related pollutants such as black carbon, NO, and UFP were frequently elevated 2 to 6 times within 150 m downwind of freeways (compared to further away), and up to twice as high within 150 m of arterial roads with significant diesel truck traffic. Wind direction was a major determinant of impacts, but elevated pollution impacts downwind of freeways and arterials were roughly proportional to diesel volumes on the roadways and nearly constant for extended periods. Thus, persons living or working near and downwind of busy roadways can have several-fold higher exposures to diesel-related pollution than would be predicted by traditional fixed-site monitors, which are sited according to USEPA criteria intended to ensure measurements representative of air quality on a large neighborhood scale.

We measured real-time air pollutant concentrations downwind of the general aviation airport in Santa Monica. Elevated UFP concentrations were observed extending beyond 660 m downwind and 250 m perpendicular to the wind on the downwind side of the SMA takeoff area. Aircraft operations resulted in spikes of highly elevated pollutants, and mean UFP concentrations elevated by factors of 10 and 2.5 at 100 m and 660 m downwind, respectively, over background concentrations. BC levels were similarly elevated. Peak UFP concentrations were correlated (r^2=0.62) with estimated fuel consumption rates for the departing aircraft. Our observations have potential health implications for persons living near general aviation airports.

In connection with the HCMS, we conducted the Harbor Communities Time Location Study (HCTLS) which integrated traditional recall diary activity logs with GPS tracking to document the patterns of 47 adult residents of port-adjacent communities, areas heavily impacted by heavy duty diesel trucks. We also conducted sampling of PM mass and number inside HCTLS participant residences during baseline and exit interviews, yielding the only indoor pollutant level data collected during the HCMS. The enhanced time-location database generated from logs, GPS and follow-up interview data significantly improved the amount (by a factor of 2) and quality of time-location data collected through recall diary activity logs alone. HCTLS participants were largely low-income, Hispanic women who on average spent about 89% of their day indoors and about 7% traveling. About one fifth of the participants resided within 200 m of a heavily-travelled roadway or truck route. On average, participants spent about 5 hours per day near roadways with high traffic volumes.

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1.0 EXECUTIVE SUMMARY

1.1 Background

Within the past decade it has been increasingly recognized that widely-spaced monitoring stations often lack the capacity to characterize localized high pollutant concentrations and steep concentration gradients arising from stationary or mobile sources. Yet extensive evidence continues to accumulate from all over the world that such localized high concentrations and gradients are critically important in determining human exposure at the individual and sub-community levels, and that persons living in close proximity to sources such busy roadways experience increased morbidity and mortality.

The ARB-sponsored Harbor Community Monitoring Study was conceived in response to the enormous growth in goods movement through the Ports of Los Angeles and Long Beach over the past two decades, and the resulting dramatic increase in air pollutant emissions in and upwind of port-adjacent communities, especially from a wide range of diesel sources. Subsequently these concerns were extended to Downtown Los Angeles an area also heavily impacted by goods movement related-activities, including heavy-duty diesel trucks and other mobile sources, and to certain sources in West Los Angeles. This research program was designed in part to address those concerns.

1.2 Methods

Real-time measurements with high spatial resolution were conducted using a mobile monitoring platform—an electric vehicle with no emissions of its own—fully instrumented to measure concentrations of particles and gases. Pollutant concentrations were monitored on driving routes in three locations in the South Coast Air Basin: communities adjacent to the Ports of Long Beach and Los Angeles in connection with the ARB-sponsored Harbor Communities Monitoring Study (HCMS); West Los Angeles; and downtown Los Angeles, including Boyle Heights. Routes were chosen primarily to investigate three environments: on-road for a wide range of surface streets and freeways; near heavily-traveled roadways, especially those with significant diesel truck traffic; and residential neighborhood areas with little or no traffic.

Measurements were conducted to investigate the key variables expected to affect the impacts from mobile sources, including time of day, day of week, season, and meteorology, especially wind speed and direction. Pollutants measured included ultrafine particles, black carbon, particle-bound polycyclic aromatic hydrocarbons, nitrogen oxide and nitrogen dioxide, carbon monoxide and carbon dioxide, many with a time resolution of less than five seconds.

In connection with the HCMS, a time-location study was conducted for 46 harbor community residents, largely low-income, Hispanic women, using both a traditional daily log approach and GPS recording of time and location.

1.3 Results

1.3.1 Near-Road Air Pollution Impacts Due to Goods Movement in Designated Impact Zones

A mobile platform was outfitted with real-time instruments to spatially characterize pollution concentrations in communities adjacent to the Ports of Los Angeles and Long Beach, communities heavily impacted by heavy-duty diesel truck traffic (HDDT). Measurements were conducted in the winter and summer of 2007 on fixed routes driven both morning and afternoon. Diesel-related pollutant concentrations such as black carbon, nitrogen oxide, ultrafine particles, and particle bound polycyclic aromatic hydrocarbons were frequently two to six times higher within 150 m downwind of freeways than further downwind) and up to two times higher within 150 m of arterial roads with significant volumes of diesel traffic.

While wind direction was the dominant factor associated with downwind impacts, steady and consistent wind direction was not required to produce high impacts, which were usually observed whenever the wind direction placed a given area downwind of a major roadway for any significant fraction of time. This suggests that enhanced pollutant concentrations downwind of freeways and of busy arterials occur on one side or the other of a busy roadway, depending on wind direction. Such impacts may also occur on both sides of the freeway for very low wind speeds or wind direction parallel to the roadway.

The observed diesel truck volumes in the area studied were more than 2,000 trucks per peak hour on the freeway and two- to six-hundred trucks per hour on the arterial roads studied. Assuming similar impacts occur throughout urban areas in rough proportion to diesel truck traffic fractions, persons living or working near and downwind of busy roadways can have several-fold higher short-term exposures to diesel vehicle-related pollution than would be predicted by ambient measurements at fixed-site monitors.

1.3.2 Wide Area of Air Pollutant Impact Downwind of a Freeway During Pre-Sunrise Hours

We have observed a wide area of elevated air pollutant concentrations downwind of a freeway during pre-sunrise hours in both winter and summer seasons. In contrast, previous studies have shown much sharper air pollutant gradients downwind of freeways, with levels above background concentrations extending only 300 m downwind of roadways during the day and up to 500 m at night. In this study, real-time air pollutant concentrations were measured along a 3600 m transect perpendicular to an elevated freeway 1-2 hours before sunrise using the electric vehicle mobile platform described above.

In winter pre-sunrise hours, the peak ultrafine particle (UFP) concentration (~95,000 cm^{-3}) occurred immediately downwind of the freeway. However, downwind UFP concentrations as high as ~ 40,000 cm^{-3} extended at least 1,200 m from the freeway, and did not reach background levels (~15,000 cm^{-3}) until a distance of about 2,600 m. UFP concentrations were also elevated over background levels up to 600 m upwind of the freeway. Other pollutants, such as NO and particle-bound polycyclic aromatic hydrocarbons, exhibited similar long-distance downwind concentration gradients.

In contrast, air pollutant concentrations measured on the same route after sunrise, in the morning and afternoon, exhibited the typical daytime downwind decrease to background levels within ~300 m as found in earlier studies. Although pre-sunrise traffic volumes on the freeway were much lower than daytime congestion peaks, downwind UFP concentrations were significantly higher during pre-sunrise hours than during the daytime; UFP and NO concentrations were also strongly correlated with traffic counts on the freeway. We associate these elevated pre-sunrise concentrations over a wide area with a nocturnal surface temperature inversion, low wind speeds, and high relative humidity.

Given that vehicle-related pollutants can penetrate indoor environments, observation of a wide air pollutant impact area in residential areas downwind of a major roadway prior to sunrise has important exposure assessment implications since most people are at home during pre-sunrise hours.

1.3.3 Observation of Pollutant Concentrations Downwind of Santa Monica Airport

Real time air pollutant concentrations were measured downwind of Santa Monica Airport (SMA), using an electric vehicle mobile platform equipped with fast response instruments in spring and summer of 2008. SMA is a general aviation airport operated for private aircraft and corporate jets in Los Angeles County, California. An impact area of elevated ultrafine particle (UFP) concentrations was observed extending beyond 660 m downwind and 250 m perpendicular to the wind on the downwind side of SMA.

Aircraft operations resulted in average UFP concentrations being enhanced by factors of 10 and 2.5 at 100 m and 660 m downwind, respectively, over a background site 880 m away from the airport (and well off the wind direction from the runway). The long downwind impact distance (i.e. compared to nearby freeways at the same time of day) was likely primarily due to the large volumes of aircraft emissions containing higher initial concentrations of UFP than on-road vehicles. Aircraft did not appreciably enhance average levels of black carbons (BC) or particle-bound polycyclic aromatic hydrocarbons (PB-PAH), although spikes in concentration of these pollutants were associated with jet takeoffs. Jet departures resulted in peak 60-second average concentrations of up to 2.2×10^{6} cm^{-3}, 440 ng m^{-3}, and 30 μg m^{-3} for UFP, PB-PAH, and BC, respectively, at a location 100 m downwind of the takeoff area. These peak levels were enhanced by factors of 440, 90, and 100 compared to background concentrations.

Peak UFP concentrations were reasonably correlated (r^2=0.62) with fuel consumption rates associated with aircraft departures, estimated from aircraft weights and acceleration rates. UFP concentrations remained elevated for extended periods associated particularly with jet departures, but also with jet taxi and idle, and operations of propeller aircraft. UFP measured downwind of SMA had a median mode of about 11 nm (electric mobility diameter), which was about a half of the 22 nm median mode associated with UFP from heavy duty diesel trucks.

The observation of highly enhanced ultrafine particle concentrations in a large residential area downwind of this local airport has potential health implications for persons living near general aviation airports.

1.3.4 Time-Location Study in Port-Adjacent Communities

The Harbor Communities Time Location Study (HCTLS) was conducted in communities adjacent to the Ports of Los Angeles and Long Beach and integrated traditional recall diary activity logs with GPS tracking and follow-up "prompted recall" surveys. This study documented the activity patterns of 47 adult residents on 131 weekdays. The enhanced time-location database generated from logs, GPS and follow-up interview data significantly improved the amount and quality of time-location data collected by means of recall diary activity logs alone. Overall, about half (49%) of participants' locations and trips in the GPS-enhanced data were not recorded on participant diary logs. Participants spent an average of over 3 hours per day in unreported locations and about half an hour per day on unreported trips.

HCTLS participants were largely low-income, Hispanic women and homemakers and, on average, spent about 89% of their day indoors and about 7% traveling. Similar to unemployed National Human Activity Pattern Survey (NHAPS) respondents of the same age, HCTLS participants spent about 78% of their day within a residence and about 5% in a vehicle. About one fifth lived near a heavily-travelled roadway and may have experienced heightened exposures to vehicle-related pollution. Participants spent about 5 hours per day on average near heavy traffic (about 3 hours inside a residence, 1 hour inside a public, service, school, or workplace location, and 30 minutes in-vehicle).

We also conducted limited sampling of PM mass and number inside HCTLS participant residences during baseline and exit interviews, yielding data on indoor particulate concentrations, the only data on indoor pollutant levels collected during the HCMS. As expected, we found substantial variation in the in-home particle count concentrations in the homes of HCTLS participants. During the 52 monitoring periods (averaging 25 minutes each) conducted in residences with at least one open window or door and no noticeable potential indoor source, the average particle number concentration (using a TSI CPC Model 3007) was ~ 25,000 cm^{-3} with the means at individual locations ranging from about 6,000 to 66,000 cm^{-3}.

1.4 Conclusion

An electric-vehicle mobile platform was used to obtain highly resolved spatial and temporal air pollutant data for both gases and particulates in three important locations in the California South Coast Air Basin. These sampling efforts quantified near-roadway concentrations of pollutants in the port-adjacent communities of Wilmington and West Long Beach, documented a wide area of pollution impact from a line source in the pre-sunrise hours, and demonstrated significant penetration of aircraft emissions into a residential neighborhood downwind of the Santa Monica airport. These discoveries illustrate the utility and power of using such a mobile platform across days, seasons and geographical areas to elucidate local effects that are not observed by traditional, widely-spaced, fixed-site monitoring networks.

Our time-location study demonstrated the value of a novel "prompted recall" approach for characterizing the time-activity patterns of port community residents. The results from this study, when coupled with the extensive air pollutant monitoring data from the HCMS, will provide valuable data for subsequent modeling of air pollution exposure of port community residents.

INTRODUCTION AND BACKGROUND

1.5 Introduction

The research described in this report was initiated as a result of a proposal solicited by the California Air Resources Board that led to the inclusion of UCLA researchers as part of the Harbor Community Monitoring Study (HCMS) by using the ARB's electric vehicle as a mobile platform (MP) instrumented for measuring pollutants throughout the community. Although the initial focus of the research was on using the MP to conduct fine spatial and temporal scale monitoring in port-adjacent communities, the contract was subsequently amended to cover several additional research and regulatory interests of the ARB, including micro-environment exposure assessment, mapping of area-wide pollution, and characterizing vehicle emissions in downtown Los Angeles (including Boyle Heights) and West Los Angeles.

A second goal of amending the original contract was to add a new research component involving collection of time-location data, using GPS-enabled cell phones as well as traditional recall diaries, for residents in the same port-adjacent communities of Wilmington and Long Beach studied in the ARB Harbor Community Monitoring Study. This time-location study when combined with monitoring data from the HCMS will facilitate modeling of exposures of port area residents. The time-location study also partially addressed a significant pollutant monitoring gap in the HCMS, the lack of information on the indoor exposure of residents due to outdoor pollution.

1.6 Statement of the Problem

For decades, the standard approach for air monitoring in California and the U.S. consisted of a relatively limited number of fixed-site monitoring stations placed across a given airshed, focused primarily on the six criteria pollutants regulated under federal and state statutes. However, within the past decade it has been increasingly recognized that such widely-spaced monitoring stations in fixed locations do not necessarily characterize the local peak concentration nor the steep concentration gradients that occur near stationary or mobile sources of pollution. Yet, air quality measurements, modeling studies and epidemiological evidence continue to accumulate from all over the world that such localized high concentrations and steep concentration gradients are critically important in determining human exposure at the individual and sub-community levels, and that persons living in close proximity to sources like busy roadways show significantly increased incidence of adverse health.

The health implications of pollutant concentration gradients adjacent to major roadways have been the focus of growing attention of regulators and legislators, especially the California Air Resources Board. Partly in response to new measurements of the decay of motor vehicle pollution away from roadways (made during daytime), the California Legislature passed regulations preventing the sitting of new schools in California any closer than 500 feet of a freeway, and attention is also being given to pre-school facilities concerning their proximity to major roadways.

The Wilmington and West Long Beach communities are surrounded by some of the most heavily traveled freeways in southern California, are home to multiple petroleum refineries and other industrial facilities, and are located adjacent to the Ports of

Los Angeles and Long Beach. These and other features of the area provide not only a complex emission source scenario but also the potential for complex pollutant concentration gradients and high exposure conditions that cannot be identified by the conventional, widely-spaced network of ambient air quality monitoring sites. Similar considerations apply to downtown Los Angeles and Boyle Heights, which are surrounded and bisected by half a dozen freeways, some of which have heavy diesel truck traffic. These situations add to the recent concerns by ARB and others about disproportionate impacts of stationary sources in minority communities as well as the potentially high exposures possible for all persons living close to sources such as busy roads. Although the South Coast Air Quality Management District and the Southern California Association of Governments conduct sub-regional and socioeconomic assessments of air pollution, our growing understanding of the health risks for populations near major roadways and major point sources emphasizes the critical need to study the highly localized impacts of emission sources by more densely mapping pollutant concentrations and concentration gradients in areas with many and varied sources of pollution.

While a single stationary monitoring station cannot capture important spatial gradients in pollutant concentrations, it may be an adequate measure of regional contributions to local concentrations and may also be adequate over longer averaging periods, but evaluating this question also requires the kind of spatially and temporally resolved data the mobile platform can generate. Prior to the HCMS there was little or no information on the range of spatial variability in vehicle-related or point source-related pollutants in this domain, or on these important variables affecting the spatial variability in these port-adjacent communities.

Similar considerations apply to downtown Los Angeles and its complex mix of sources, many of which are mobile on surface streets, highways and freeways. A single fixed-site monitoring station in the downtown region is inadequate to map the spatial impacts of the many line sources crossing the downtown area. Here again the value of a mobile monitoring platform is apparent. Finally, the west side of Los Angeles is also of interest due to the perception of a generally cleaner vehicle fleet but the location of specific important pollution sources such as the Santa Monica airport.

1.7 Background

1.7.1 Mobile Platform Studies

1.7.1.1 Air Quality On and Near Roadways

Air quality in the vicinity of roadways can be seriously impacted by emissions from heavy traffic flows. As a result, high concentrations of air pollutants are frequently present in the vicinity of roadways and may result in adverse health effects in the on-road and near-roadway microenvironments. These include increased risk of reduced lung function (e.g., Brunekreef 1997), cancer (e.g., Knox and Gilman 1997; Pearson et al. 2000), adverse respiratory symptoms (e.g., vanVliet et al. 1997; Venn et al. 2001; Janssen et al. 2003), asthma (Janssen et al. 2003), and mortality (Hoek et al. 2002), and pre-term birth (Ritz et al. 2000; Ren et al. 2008).

Pollution near roadways involves a large number of pollutants, including carbon monoxide, nitrogen monoxide and dioxide, various toxic organics and particulate matter.

While PM2.5 is typically only moderately elevated near roadways relative to surrounding areas, ultrafine particles (PM0.1, or UFP) are highly elevated relative to areas further from roadways. Because UFP coagulate rapidly and become incorporated into the fine mode as they move away from their source, combined with dilution, their concentrations generally drop rapidly away from freeways (Zhu et al. 2002a; Zhu et al. 2002b (Zhu et al. 2002a; Zhu et al. 2002b; Zhang and Wexler 2004; Zhang et al. 2004; Jacobson et al. 2005).

Recently, attention to ultrafine particles has intensified, particularly in the toxicological and exposure communities, and while the health impacts of UFP are far from completely understood, a picture is emerging. Short term high concentrations of ultrafine particles appear likely to be responsible for increases in all-cause mortality, hospital admissions for cardiovascular and respiratory diseases, aggravation of asthma and reduced lung function (Knol et al. 2009). The effects of longer term exposures are more debated, but include the above list in addition to lung cancer (Knol et al. 2009).

Pollutant gradients near freeways have been recognized at least since the 1980s, with most measurement data concentrated during daytime. Early studies focused on gas phase pollutants (Rodes and Holland 1981). Hitchins et al. (2000) measured concentrations of fine and ultra-fine particles at a distance of 15 to 375 m from a major roadway during the daytime. They found concentrations decayed to about half of the peak value (at the closest point to the roadway) at approximately 100-150 m from the roadway on the normal downwind side. Particle concentrations were not affected by the roadway at a distance farther than 15 m on the normal upwind side, indicating a sharp gradient of fine and ultrafine particles. Similar studies were conducted by Zhu et al. (2002a, b), who measured ultrafine particles (UFP), CO, and black carbon (BC) along the upwind (200 m) and downwind (300 m) sides of a freeway in Los Angeles during the daytime. Peak concentrations were observed immediately adjacent to the freeway, with concentrations of air pollutants returning to upwind background levels about 300 m downwind of the freeway.

The few near-roadway studies conducted at night indicated larger areas of impact than during daytime. UFP concentrations at night were reported by Zhu et al. (2006) , who conducted measurements upwind (300 m) and downwind (500 m) of a freeway from 22:30 - 04:00. Although traffic volumes were much lower at night (about 25% of peak) particle number concentrations were about 80% higher 30 m downwind of the freeway compared with the day, with UFP concentrations of ~50,000 cm^{-3} about 500 m downwind of I-405, a major Los Angeles freeway during the night. Fruin and Isakov (Fruin and Isakov 2006) measured UFP concentrations in Sacramento, California, near the US-50 Freeway between 23:00 and 01:00 and found 30-80% of maximum centerline concentrations (measured on a freeway overpass) 800 m downwind. More recent gradient results by our group are discussed in Section 3.1.3.2 below.

1.7.1.2 Instrumented Vehicle Studies

Instrumented vehicles, or mobile platforms, began to be employed first in the 1980's, and have been more widely implemented beginning about 15 years ago. They have been used for several research goals: (a) to measure pollutant levels on-board vehicles (i.e., "in cabin" concentrations) under realistic driving conditions; (b) to make mobile measurements of pollutant concentrations on roadways (rather than making measurements alongside roadways from fixed sites); (c) for special studies, in which the mobile platform is used to do essentially stationary measurements on a fine scale at a set of locations in close proximity to either a source (e.g. airports) or receptor of interest; (d) to characterize the decay of pollutant levels with increasing distance from roadways and other concentrated sources; (e) and to look for 'hot spots' and areas of anomalously elevated pollutant concentrations in residential and other areas; and (f) "chase" studies to directly sample vehicle plumes for dilution rates and particle size distribution information. In the following sections we briefly cite examples of such studies, some of which represent antecedents to the study proposed here. This summary of earlier studies is meant to be illustrative and is not inclusive of all such studies.

A steady stream of recent results have been produced by researchers at the Air Resources Board (ARB), and a handful of additional institutions using the same ARB - maintained mobile platform (Westerdahl et al. 2005; Fruin et al. 2008; Westerdahl et al. 2008.

One of these studies focused on airport emissions, reporting highly elevated concentrations of ultrafine particles, and several other pollutants (Westerdahl et al. 2008). Ultrafine particles are of particular interest because aircraft exhaust produces very high concentrations of very small particles, which show up only weakly if at all in mass-based measurements. The study by Westerdahl et al. (2008) measured concentrations of ultrafine particles (UFP), particle-bound polycyclic aromatic hydrocarbon (PB-PAH), black carbon (BC), and NO_x in the vicinity of Los Angeles International Airport (LAX). They observed markedly high UFP concentrations of about 5.0×10^{5} cm^{-3} 500 m downwind of the takeoff runways (Westerdahl et al. 2008). The observed downwind UFP number concentrations were dominated by freshly generated particles with peak modes of 10-15 nm. Upwind UFPs were dominated by aged particles with a mode of about 90 nm.

1.7.1.3 <u>In-Vehicle Pollutant Concentrations</u>

A growing number of studies have characterized in-cabin conditions in passenger cars, school buses and transit buses. Shikiya et al. (1989) conducted the earliest reported comprehensive in-vehicle concentration study. 140 cars in the South Coast Air Basin were measured for CO, 4 metals and 12 VOCs in the summer of 1987 and winter of 1988. In-vehicle concentrations were generally two to four times higher than those concentrations measured at ambient monitoring stations. For example, in-vehicle concentrations of benzene and CO were about 13 ppb and 8 ppm, respectively, versus ambient concentrations of about 3 ppb and 2 ppm. These findings were confirmed by later passenger car studies in the U.S. showing that in-vehicle concentrations of CO and fuel-related VOCs were significantly higher than those in ambient air (Chan et al. 1991a; Chan et al. 1991b; Lawryk et al. 1995)

A follow-up study by Rodes et al. (1998) was the largest and most comprehensive in-vehicle concentration study conducted up until its time. It was conducted in the fall of 1997 and consisted of 29 two-hour runs, 13 conducted in Sacramento and 16 in Los Angeles. Sixty-second averages of CO, fine particle count, and black carbon concentrations were recorded, with integrated two-hour VOCs from canisters and PM10 and PM2.5 from filters, later analyzed for elemental composition. Overall, the in-vehicle-to-ambient ratios were five to ten times for CO and 1,3-butadiene, four to eight times for aromatic compounds and MTBE, and two to four times higher for formaldehyde.

In moderate to heavy traffic, vehicle occupants are primarily exposed to the exhaust of the vehicle being followed, as well as neighboring vehicles. A limited number of studies have investigated the impacts of the exhaust location and type of vehicle on occupants exposure in the following vehicle. Fruin et al. (2004) analyzed the Rodes et al. (1998) data to show that for a typical California driver one third to one half of their 24 hr exposure to diesel exhaust particulate came from the 6% of the time on average they spent driving.

School buses present a special case of in-vehicle exposures because they appear to be particularly vulnerable to re-entrainment of their own emissions. To date approximately a dozen studies of pollutant concentrations aboard school buses, with a focus on diesel powered buses, have been conducted in North America, although with several exceptions (Behrentz, et al. 2002; Sabin et al. 2005) most of these studies have not been reported in the peer-reviewed literature (e.g., Brauer et al. 2000; Solomon et al. 2001; Fitz et al. 2002; Weir 2002; Maybee et al. 2004). Consistent with results from passenger car studies, these studies showed significantly elevated concentrations of diesel gasoline exhaust pollutants relative to ambient air, and in several of these studies, elevated concentrations above roadway concentrations due to entrainment of the bus's own emissions (Solomon et al. 2001; Behrentz et al. 2004).

Within the past five years there has been intense focus on measurement of ultrafine particles (UFP) since such particles are increasingly implicated in human health effects. One of the direct antecedents for the present project, Westerdahl et al. (2005) and Fruin et al. (2008) utilized the ARB's non-polluting mobile platform together with multiple scanning mobility particle sizers to conduct measurements of UFP and associated pollutant concentrations on freeways and residential streets in Los Angeles. These studies showed freeway on-road UFP concentrations to be largely driven by truck emissions while hard accelerations of gasoline-powered vehicles appeared to be the most common source of high UFP concentrations on arterial roads.

In other in-vehicle studies of UFP, Miguel and co-workers (Zhu et al. 2007) conducted mobile monitoring in Los Angeles using a passenger car equipped with a HEPA filter system, including measurement of in-cabin and roadway measurements for both freeways and surface streets. Hitchins et al. (2000) and Kittleson et al. (2004a) have also measured high concentrations of UFP on and near roadways. Several mobile monitoring studies that included UFP measurements have been conducted in Europe (Bukowiecki et al. 2002; Pirjola et al. 2004; Weijers et al. 2004) and in the eastern United States (Canagaratna et al. 2004; Kittelson et al. 2004a; Kittelson et al. 2004b) .

1.7.1.4 Harbor Community Monitoring Study

The ARB-sponsored Harbor Community Monitoring Study was conceived in response to a tripling in goods movement through the Ports of Los Angeles and Long Beach over the past two decades (Port of Los Angeles TEU statistics: http://www.portoflosangeles.org/maritime/stats.asp; and Port of Long Beach TEU archives http://www.polb.com/economics/stats/teus_archive.asp) , and the resulting dramatic increase in air pollutant emissions in and upwind of port-adjacent communities, especially from a wide range of diesel sources. Under this ARB contract UCLA researchers, working closely with ARB staff and Dr. Scott Fruin of the USC Preventive Medicine Department, as well as with other investigators involved in the Harbor Community Monitoring Study, have been responsible for the mobile platform research component of the HCMS. After equipping a RAV4 electric vehicle with a full range of real-time gaseous and particulate pollutant monitors, we conducted a pilot study and winter and summer field monitoring campaigns in the port adjacent communities of Wilmington and Long Beach. With 10 days of sampling in winter and 14 days in summer, a wealth of information was collected concerning on-road, neighborhood, 150 m buffer, and in-vehicle pollutant concentrations on carefully designed routes within these communities, during morning and afternoon sampling runs characterizing different traffic and meteorological conditions. With the winter and summer campaign we were also able to make seasonal comparisons for these data (e.g. based on significantly different meteorological conditions).

1.7.1.5 Downtown Los Angeles, Boyle Heights and West Los Angeles

Using similar approaches to those employed in the HCMS with regard to route selection and monitoring protocols, this research project was subsequently expanded to winter and summer monitoring campaigns in West Los Angeles and Downtown Los Angeles, including Boyle Heights as discussed above and below. This overall mobile platform research has demonstrated the great versatility and power of using an instrumented electric vehicle to rapidly collect pollutant concentration data over a wide range of microenvironments and with excellent spatial and temporal resolution, leading to the key research discoveries and findings described in this report.

1.7.2 Harbor Community Time-Location Study

Previous time-location studies have largely relied on interviews and diaries. Recent work suggests that portable Global Positioning Systems (GPS) technology offers a valuable new tool to (a) track subject locations throughout the day as they go about their everyday activities in various microenvironments and (b) validate conventional time-activity diaries (Phillips et. al., 2001). GPS-based methods can enhance retrospective surveys by tracking “actual” travel rather than self-reported travel, by reducing respondent reporting burden, by reducing the requirement for respondents to report travel and location details, by enabling the collection of multiple-day activity data and supplemental information, and by reducing respondent reporting fatigue (Murakami and Wagner, 1999). Since GPS offers the potential of increasing data collection efficiency and reducing participant’s burden of filling out a daily activity record, it can be used to track subjects for longer periods of time, providing valuable data on within-subject variation (Xue et al., 2003) which is necessary to refine exposure assessment methodologies.

GPS tools provide temporal and location data on time-location activity patterns which can be used to more accurately classify subjects into location categories (in-vehicle, indoor and outdoor microenvironments) in air pollution exposure assessment studies, especially given potential recall errors in traditional time-activity diaries (Elgethun et al., 2003). Comparisons of diary and simultaneous GPS location data suggest that data derived from diaries underestimates time indoors at home, and overestimates time spent outdoors, in transit, and indoors at other locations (Elgethun et al., 2007).

Transportation studies also identify substantial underreporting of trips using simultaneous diary-GPS monitoring and demonstrate ways that GPS technologies can provide a valuable audit and verification tool for time-locations studies (Zmud and Wolf, 2003). Analysis of the Caltrans' 2000-2001 California Statewide Household Travel Survey and the 2001/2 Los Angeles Regional Travel Study identified that recall methods underreported as many as 20% of household trips; low socio-economic (SES) households were more likely to underreport travel, and shorter trips and short stops on a longer trip were more likely to be underreported (California Department of Transportation, 2002; Zmud and Wolf, 2003; Zmud, 2003).

Recent advances in portable GPS technologies lower respondent reporting burden and enable more continuous monitoring or "person tracking" across various travel modes and activities. The weight and size of the portable GPS units in early studies used in the 4-day 1999 pilot project monitoring 150 individuals in the Netherlands could have resulted in respondent resistance to carrying GPS for walking, biking, and transit trips and for shopping or visits (Draijer et al., 2000 as cited in Kracht (2004) and Bhat (2004)), but monitoring with portable GPS-enabled cell phones can reduce respondent burden and enable more continuous monitoring of participants' microenvironments (Elgethun et al., 2003).

A challenge to portable GPS monitoring is that the signal reception of GPS units can vary by location and transportation mode. De Jong (2003) indicates GPS tracking quality in trains and buses varies by the characteristics of the vehicle (e.g., presence of windows) or the position of the rider (e.g., location relative to windows). Nielson and Hovgesen (2004) reports that compared to other travel modes the most consistent GPS signal reception using GPS-enabled phones was during bicycle and car travel except in denser areas with taller buildings which could "block" GPS satellite signals. GPS signal was also consistent during pedestrian travel, but was unavailable during transit by underground train and was less consistent traveling by bus above ground. Although Elgethun et al. (2003) also indicates that signal interference occurs in some locations (inside or near concrete/steel-frame buildings), they confirm that GPS-enabled cell phones lower respondent burden and provide adequate geographic resolution and temporal precision for assessing outdoor and in-vehicle locations.

Prompted recall (PR) techniques can been used to overcome the challenge of GPS signal loss by allowing participants to verify suspected activities, locations, and microenvironment characteristics. First used by Bachu et al. (2001), this approach identifies discrepancies between information provided in travel diaries versus simultaneous GPS traces then asks respondents in follow-up surveys using tabular and mapped data to confirm trips and their characteristics (Doherty et al., 2006). A pilot study by Stopher et al. (2002) suggests this technique can be used to increase the accuracy of reported data even after a lapse of up to 14 days from the time of travel. Flamm (2007) also found that the use of GPS-based maps to illustrate suspected unreported or unclear travel patterns in exit interviews greatly improved the accuracy of monitoring and provided the identification of erroneous "trips" even when such interviews were conducted 7-10 days after the travel occurred. Wolf et al. (2004) reports that mailed PR surveys of 27 GPS households in the 2004 Kansas City Regional Household Travel Survey provided invaluable insight into the purposes of unreported travel and the explanations of why underreporting occurs from the respondent perspective.

Although substantial stationary and mobile monitoring has been conducted in the near-port communities of Wilmington and western Long Beach during the Harbor Communities Monitoring Study, relatively little is known about the time-location activity patterns of residents and their associated in-vehicle, indoor and outdoor exposure to these pollutants. A particular gap in the HCMS overall integrated study was the lack of indoor measurements. Although such measurements were beyond the scope of the HCMS, the collection of household and building characteristics data through appropriate questionnaires as was conducted in this study, may allow subsequent modeling of the intrusion of outdoor air into indoor microenvironments. Such data, when coupled with the time-location data proposed to collected here from GPS-enabled phones and T/A diaries may provide a basis for assessing indoor exposure to pollution generated by port- and refinery-related activities. We also made limited in home measurements of particulate matter (PM) during the initial and exit interviews conducted for the HCTLS.

1.8 Overall and Specific Objectives

1.8.1 Mobile Platform Studies

1.8.1.1 Overall Objective

The overall objective of this portion of the project was to conduct a mobile platform monitoring program in the port-adjacent communities of Wilmington and West Long Beach and two other areas of the South Coast Air Basin, Downtown Los Angeles (DOLA) and the Westside of Los Angeles (WLA); gradient measurements across major roadways (e.g. freeways) during the pre-sunrise hours; and additional in-vehicle measurements.

1.8.1.2 Specific Objectives

The specific objectives of the MP study were to:

(1) Conduct a mobile platform monitoring program in the port-adjacent communities of Wilmington and West Long Beach as a function of key variables likely to affect pollutant concentrations and gradients, including time of day, day of week, season and meteorology. To investigate three main microenvironments: on-road, near roadway and in residential neighborhood areas with little or no traffic.

(2) Extend the MP study in port-adjacent communities to other two other areas of the SoCAB heavily impacted by vehicle traffic and other emission sources: the Westside of Los Angeles and Downtown LA. Such measurements are not only of value per se, but may also permit answering the question how do the measurements made in port-adjacent communities compare with those made in DOLA which is dense with major freeways and goods movement related activities, or the Westside of LA, where traffic densities and volumes are highest for gasoline vehicles.

(3) Make stationary measurements in key 200 meter "buffers" that represent important exposure microenvironments downwind of line sources with heavy gasoline, and where applicable, diesel traffic. Specifically to conduct "buffer" measurements in locations where the numbers of people exposed to near-roadway pollution are expected to be high.

(4) Conduct measurements in the early morning hours before sunrise. Previous research by Hinds and co-workers (2007) show that the "buffer" for ultrafine particles, black carbon and CO extends out to as much as 600 meters downwind of freeways in the early morning hours, three times farther than during the day. They also found pollutant levels are higher in the midnight to 06:00 period than during the day, even though traffic flows are much lower in the early morning hours.

(5) Conduct measurements downwind of a regional airport such as Santa Monica Airport.

1.8.2 Time-Location Study Using Integrated Diary, GPS and Prompted Recall Methods

1.8.2.1 Overall Objective

The overall goal of the study was to provide a time-location activity database for selected residents in the lower SES communities of Wilmington and western Long Beach that can be subsequently used in principle to model in-vehicle, indoors, and outdoor exposures to air pollution monitored in the Harbor Communities Monitoring Study. A secondary overall objective was to demonstrate and evaluate the use of GPS-based time location data and prompted recall follow-up interviews to validate and enhance traditional time-activity diary data for classifying subjects into microenvironment location categories (in-doors, outdoor, and in-vehicle).

1.8.2.2 Specific Objectives

The specific objectives of this portion of the study were to:

(1) Collect baseline data on household behaviors and home structural characteristics that will permit subsequent modeling of the penetration of outdoor air pollution measured in the HCMS into the home microenvironment.

(2) Obtain limited real time PM measurement data (PM2.5 and/or UFPs) in the homes of the study participants during initial and exit interviews.

(3) Obtain and validate data on time activity patterns of port-adjacent residents in microenvironment location categories using three days of simultaneous diary-GPS activity monitoring and follow-up prompted recall interviews.

(4) Collect extended GPS time-location data on the time port-adjacent residents spend in microenvironment location categories in order to generate a more robust time-location database and to enable future analysis of within-subject variation in time-activity patterns.

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2.0 EXPERIMENTAL METHODS AND STUDY DESIGN

2.1 Introduction

In the following sections we describe in detail the instruments, study designs, routes and protocols used to accomplish the objectives given above. A large number of mobile platform runs were conducted over the course of this research. All of the data collected during this project has been submitted to the ARB for potential additional analysis.

2.2 MP Vehicle

The research vehicle, or mobile sampling platform, employed in this study was a 2003 electric Toyota RAV4 sub-SUV. An electric vehicle (EV) is desired because of its non-polluting propulsion, and the RAV4 EV is capable of transporting substantial weight, and is easily modified to accommodate the instrument package employed (see below). This vehicle has a range of approximately 80 miles at speeds up to 70 miles per hour.

Recharging of the RAV4 and the instrument battery pack between monitoring run days, as well as between morning and afternoon runs, occurred at the Particle Instrument Unit (PIU) of the Southern California Particle Center Supersite (SCPCS) located near downtown Los Angeles, except for recharging in the middle of the day during the HCMS which took place at the Harbor Authority Building in San Pedro.

2.3 Instruments

Table 3.3.1 presents a list of instruments used in this study, including the parameters measured and the time resolution of the corresponding instrument. The pollutants selected for investigation in this project included ultra-fine particles, PM2.5, CO and CO_2, oxides of nitrogen and black carbon. The health-related basis for focus on these pollutants is well established. Particulate matter (e.g. PM2.5) has been associated with mortality and a wide range of morbidity effects (Brunekreef, et al. 1995; Dockery, 2001; Dockery et al., 1993; Pope et al., 1995), while UFP are the subject of intense investigation concerning their potential health effects (Hauser et al., 2001; Oberdorster, 2001; Li et al. 2003; Cho et al. 2005; Delfino and Singh, 2005; Brugge et al., 2007; Ntziachristos et al., 2007). The health effects of nitrogen dioxide and carbon monoxide, both criteria pollutants, are well established.

Since sharp gradients were not found in earlier studies for PM2.5, we recognize that PM2.5 is most properly classified as a regional "background" pollutant, with a large secondary formation contribution. Zhu et al. (2002a, b) and others have demonstrated that PM2.5 concentrations are not highly sensitive to line source emissions, in contrast to black carbon and CO concentrations or particle number. Thus, PM2.5 is not an obvious choice for measurement given that the focus of the present study is in large part on characterizing vehicle-related pollutant concentration gradients. However, PM2.5 is critically important from a regulatory standpoint because it has been associated with both mortality and a wide range of morbidity effects. Thus, for completeness and to support further model development and testing, PM2.5 was measured in this project.

It is well established that CO_2, CO, black carbon, particulate-phase PAH and NO_x are associated with either diesel or gasoline vehicle exhaust, or both. Westerdahl et al. (2005) measured UFP and associated pollutants such as NO_x and black carbon on southern California roads and freeways and found that average concentrations of UFP varied by location, road type and truck traffic volumes. Real time measurements of black carbon and NO_x were highly correlated with UFP number. Measurements of in-cabin CO_2 also correlated well with UFP concentrations. CO_2 concentration measurements can also serve to identify periods when our test vehicle was in the plume of another vehicle during mobile sampling. CO emissions occur primarily from gasoline-powered vehicles and these measurements can be used to distinguish between gasoline and diesel vehicle influences.

2.3.1 Ultrafine Particles

The TSI Condensation Particle Counter Model 3007 is capable of measuring particle counts in the size range from 10 nm to >1 um and up to 100,000 particles/cm^3. This instrument draws the aerosol sample continuously through a heated saturator, where alcohol is vaporized and diffuses into the sample stream. This mixture of aerosols passes into a cooled condenser where the alcohol becomes supersaturated. Particles present in the aerosol sample stream serve as condensation sites for the alcohol vapor, causing the particles to grow quickly into alcohol droplets. These droplets pass through an optical detector where they can be counted.

Ultrafine particle concentrations and size distributions were measured with a TSI 3091 FMPS (fast mobility particle sizer). The instrument draws an aerosol sample and positively charges the particles. The charged particles are sent down near a high voltage electrode column via HEPA filtered sheath air. A positive charge is applied to the electrode, repelling the particles outward according to their electrical mobility. Particles with high electrical mobility strike electrometers toward the top of the column, whereas those with low electrical mobility strike electrometers lower in the column. These charges are then measured.

2.3.2 PM2.5 Mass

PM2.5 measurements were made using a TSI Model 8520 DustTrak Aerosol Monitor. The DustTrak is a nephelometer that senses particle scattering of a laser beam and converts signals into a particle mass reading. The PM concentration circumventing the impactor is determined by measuring the intensity of the 90° scattering of light from a laser diode. The instrument sample flow rate is 1.7 L/min and an averaging time of 1 second was used. The instruments are calibrated at the factory with Arizona road dust (NIST SRM 8632).

Our experience with this instrument during our previous school bus study (Fitz et al., 2003; Sabin et al., 2005) paralleled that of other investigators (Ramachandran et al., 2000; Yanosky et al., 2002; Chung et al., 2001). In particular, the greatest utility of the DustTrak is to obtain relative measurements of PM2.5 with high time resolution, rather than rely on this instrument for absolute PM2.5 mass.

Table 2.3.2.1. Instruments and measurement parameters

Instrument	Measurement Parameter	Resolution	Response Time	Detection Limit
TSI Portable CPC, model 3007	UFP Count 10 nm-1um	1 particle/cm3	<9 s, for a 95% response	10 nm, <0.01 particles/cm3
TSI FMPS	UFP Size 5.6-560 nm	1 size distribution/s	1 s	5.6 nm
TSI Model 8520 DustTrak	PM2.5	±0.001 mg/m3	10 s	0.001-100 mg/m3, 0.1-10 µm size range
Magee Scientific Aethalometer	Black Carbon	Proportional to flow rate	90 s	1 µg/m3
Photoacoustic Spectrometer	Black Carbon			
EcoChem PAS 2000	Particle Bound PAH	2 s time resolution	<10 s	3 ng/m3
TSI Q-Trak Model 8554	Carbon Monoxide (CO),	0.1 ppm (CO)	60 s (CO)	0.1 ppm (CO)
	Carbon Dioxide (CO2)	1 ppm (CO2)	30 s (CO2)	1 ppm (CO2)
Teledyne API 300e CO Analyzer	CO	0.5% of reading	10 s	0.04 ppm
LI-COR, LI-820 CO2 Gas Analyzer	CO2	<2.5% of reading	<10 s	3.0 ppm
Teledyne-API NOx analyzer, model 200e	Nitrogen Oxides			
	(NOx, NO, NO2)	0.5% of reading	20 s	0.4 ppb
Garmin GPSMAP 76CS	GPS	±3 meters	1 s	0.05 m/s
Vaisala Sonic Anemometer and Temperature/RH Sensor	Local Wind Speed and Direction, Temp, RH	0.1 m/s, 1 deg, %^	1 s	<1 m/s
Stalker LIDAR and Vision Digital System	Traffic Documentation, Vehicle Distance and Relative Speed	1 s	NA	NA

Note: for a 10 sec response time and vehicle speeds of 15, 30, and 45 mph, the measurement response distance would be about 65, 140, and 185 meters, respectively; for a 1 sec response time the equivalent distances are about 6, 14 and 18 meters.

2.3.3 Black Carbon

Black carbon concentrations were measured using two real-time Magee Scientific aethalometers. The aethalometer draws sample air through a 0.5 cm^2 spot on a quartz fiber filter tape. Infrared light at 880 nm is transmitted through the quartz tape and detected on the back side of the tape using photodetectors (one detector senses the light transmitted through the spot where the air was drawn through and the second detected light transmitted though an unused section of tape in order to correct for changes in the light source intensity and changes in the tape characteristics). Decreases in the amount of light transmitted through the spot on the quartz tape are proportional to the amount of elemental carbon and "heavy" organic molecules collected. The instrument's response to the change in light transmittance is reported as "black carbon" (BC). The instrument's sample flow rate is maintained using mass flow controllers.

The concentration of BC in units of mass of BC per volume of air (e.g. "$\mu g/m^3$") is determined by the instrument from the flow rate and change in light transmittance data. When the light transmittance through the collection spot on the quartz filter decreases by seventy-five percent, the quartz tape automatically advances to a fresh section of filter. Each time the filter tape automatically advances, the instrument recalibrates for approximately one minute prior to restarting sampling. In the current MP study we have employed two aethelometers, a standard model and an extended range model for which there are longer periods between advances of the filter tape.

2.3.4 Particle-Bound Polycyclic Aromatic Hydrocarbons (PB-PAH)

An EcoChem Model PAS 2000 analyzer was used to measure concentrations of particle-bound PAH. This instrument uses a UV lamp to photo-ionize PAH components of particles. An electric field is then applied to remove negatively charged particles. The positively charged particles are collected on a filter and the total charge collected is measured with an electrometer; the charge collected is proportional to the concentration of PB-PAH. The sensitivity of the instrument is approximately10 ng/m^3.

2.3.5 Carbon Dioxide and Carbon Monoxide

Carbon dioxide (CO_2) was measured with a LI-COR CO_2 Gas Analyzer, Model LI-820. This instrument uses an absolute, non-dispersive, infrared (NIDR) gas analyzer based on a single path, dual wavelength infrared detection subsystem. CO_2 measurement is a function of the absorption of IR energy as it travels through an optical path. The concentration measurements are based on the ratio of IR absorption between the sample signal and reference signal.

CO was measured with the API model 300e, an EPA approved CO monitor. The 300e has a response time of approximately 20 seconds and measures CO by comparing infrared energy absorbed by the sample to that of a reference.

2.3.6 Oxides of Nitrogen

An API-Teledyne Model 200e instrument was used to measure oxides of nitrogen. This device utilizes chemiluminesence to detect nitric oxide (NO). Other oxides of nitrogen (e.g. NO_2) are converted to NO for measurement. The instrument reports NO, total oxides of nitrogen (NO_x), and calculates NO_2 by subtracting NO values from NO_x. The Model 200e unit is an analyzer designed for routine ambient air monitoring applications and has performed well in mobile operation for us in the current MP study.

2.3.7 Verification of Vehicle Location using GPS

Vehicle location and speed were determined with a Garmin GPSMAP 76CS global positioning system with a Wide Area Augmentation System (WAAS) corrections system. The system provides position accuracy of about 2-3 m and velocity accuracy of 0.05 m s^{-1} while moving at steady state. In addition to horizontal position (e.g. latitude and longitude or UTM coordinates), the corrected GPS system also provides elevation and velocity data.

The GPS unit was also used as a time reference during this study. The clocks on all other devices were set to the GPS time on a daily basis

2.3.8 Meteorological Data

Local meteorological data conditions were collected with Vaisala WS425 sonic anemometer on-board the platform. This instrument describes the 2-D horizontal wind velocity using three transducers in an equilateral triangle. The measuring range for this instrument is between 0 to 65 m/s with a resolution of 0.1 m/s.

Temperature and relative humidity were measured with a Vaisala HUMICAP® Humidity and Temperature probe.

In the current study, these measurements were collected during the test runs by stopping for several minutes during runs to capture meteorological conditions at that particular location and time. Data from stationary monitoring stations were used to supplement these data.

2.3.9 Traffic Documentation

A Stalker Digital Vision System was used to record traffic conditions in the lane in which the vehicle was traveling during all measurement periods, as well as the adjacent lanes. The date/time, relative vehicle speed and distance were “stamped” onto the video footage. The video camera helped identify emission sources (e.g. individual vehicles) and the integrated microphone system provided as an oral record of driver observations. The clock in the video camera was synchronized with the GPS master clock time prior to each run.

2.3.10 Data Logger

A Eurotherm Chessell 6100A graphic data acquisition recorder was used for data collection. The 6100A has a 5.5" color touch screen display and 18 input channels with up to 32 MB of internal Flash memory (upgraded to 256 M in July, 2008) for secure, short term, data storage and has a removable PC Flash Card slot accessible from the front. Data stored within the internal memory can be archived to the Flash card on demand or at preset intervals. The 6100A provides an indication of how long its internal memory and that of the removable media installed will last according to the configuration of the recorder. Data are stored in a tamper-proof binary format that can be used for secure, long term records.

In addition to archiving data in the 6100A flash drive, data were downloaded to a laptop computer on a daily basis (at the end of each run).

2.3.11 Calibrations

Calibrations of the gas analyzers were conducted at the beginning and end of each 4-week sampling period along with semi-monthly zero and span calibration checks, weekly flow checks, and daily zero checks for particulate analyzers. For calibrations, a standard gas containing a mix of NO and CO was diluted using an Environics 9100 Multi-Gas Calibrator and Teledyne API Zero Air System (Model 701) to calibrate the CO and NO/NO_x analyzers. CO_2 was calibrated with zero air and span gas cylinders from Thermo Systems Inc. Flow measurements were conducted with a DryCal DC-lite flow meter with a flow range of 7 l min^{-1} to 100 ml min^{-1} with an accuracy of ±1%. Bi-monthly calibration checks of the gas analyzers exhibited 10-12% accuracy when challenged with the standard gas. Weekly flow checks indicated flows varied by no more than 5% for any given week.

2.3.12 Instrument Packaging and Power Supply

Instruments were powered by a 2-kW/115-V inverter connected to 4 sealed lead-acid batteries, providing for up to 6 hours of continuous instrument operation when the batteries were new and allowed to fully charge. The durability of power supply dropped to about 3 hours on 3-4 days during the end of summer campaign.

2.4 Route and measurement times

As discussed earlier, a primary goal of this project was to map concentrations and gradients over a representative area as a function of key variables such as time of day, day of week and season. For each study, several routes were evaluated to test their appropriateness for capturing key exposure scenarios, including incorporating a full range of line source categories, from neighborhood surface streets with little traffic to major surface street arterials, to the most highly trafficked freeways in the nation.

2.4.1 Ports and Wilmington Area

The Harbor Communities are bounded by the 110, 405, and 710 freeways, some of the most heavily traveled in Southern California. Wilmington is home to multiple petroleum refineries, other industrial facilities, commercial businesses, and is located just north of the Ports of Los Angeles and Long Beach; the Alameda Corridor, which supports a tremendous rate of locomotive traffic, runs through the eastern portion of this community. One of the largest sources of pollution in the Harbor Communities is the Port of Los Angeles and Long Beach; in particular, the heavy-duty diesel trucks (HDDT) that travel from the shipyards through these communities. Often, these trucks travel short distances and are poorly maintained. Thus, these trucks are likely to have higher emissions of diesel-related pollutants. Up to 600 trucks per hour have been observed at various intersections in the Harbor Communities for several hours a day (Houston et al., 2008).

The expansion of the port and the dramatic increase in goods movement (tripling in the last 15 years) has led to a significant increase in container traffic through the port, increasing all port-related activities, and port-related emissions. Diesel truck traffic, in particular, has had a large impact on community exposures as heavy-duty diesel trucks travel on streets adjacent to residential neighborhoods. To assess and characterize the truck traffic from the ports, the University of California Transportation Center (UCTC) conducted a study to perform truck traffic counts at busy intersections in the Wilmington area. The study found up to 600 trucks per hour were observed at several locations (Houston et al., 2007), most of which were upwind and within close proximity of eating establishments, gas stations, and other locations where people spend their time. Examples of these locations include the intersections of Santa Fe Avenue and Pacific Coast Highway (PCH) and also Santa Fe Avenue and Anaheim Street. Both Anaheim Street and PCH near Santa Fe Avenue are heavily impacted by HDDT traffic. The intersection at Santa Fe and PCH in particular had increased pedestrian traffic due to its close proximity to schools and the numerous eateries and gas stations at the intersection. Both intersections were included in the mobile platform fixed driving routes shown in Figure 3.4.1.1 The importance of this 200 meter buffer zone was demonstrated in Zhu et al. (2000 a, b) and is discussed in the next section.

The freeways and petroleum refineries are also important pollution sources that may impact residences or schools in immediate proximity. The I-710 and Terminal Island freeways have high levels of heavy-duty diesel truck traffic and are closely situated near residences and schools. Petroleum refining facilities may also have impacts on nearby residences, particularly during upset conditions.

2.4.1.1 Route development for Ports study

The mobile platform was driven on two routes during the study: the Residential Route and the Port/Freeway/Truck Route (PFT). The PFT Route was developed to capture impacts from HDDTs and other port-related emissions while the Residential Route was developed to investigate pollution concentrations and gradients at the neighborhood level. A map of the PFT and Residential Routes is shown in Figure 3.4.1.1, including meteorological and stationary monitoring locations. The routes traveled through the cities of Carson, San Pedro, Wilmington, and West Long Beach. Both routes were about 30 miles long and driven two times per day (once in the morning between 8:00 and 11:00 and once in the afternoon between 14:30 and 17:00), 2-3 times per week, in the winter and summer seasons. For all runs, the in-car video recorded vehicles in front of the mobile platform. Audio was also recorded to keep track of events not recorded by the video.

2.4.1.2 Stationary Monitoring at Heavily-Impacted Intersections

Due to relatively high traffic density at intersections, and the frequency of high emissions from hard accelerations, stationary monitoring was conducted at several key intersections heavily impacted by HDDT traffic. These locations were frequently trafficked by pedestrians, persons waiting for buses, and persons stopping at fast food restaurants and gas stations. Monitoring was conducted 10 to 15 m from the nearest intersection corner at these locations for 5-10 minutes during morning and afternoon sampling. The video camera was pointed toward the intersection to capture HDDTs crossing through the intersection during each light cycle. One of the most impacted stationary sites, shown in Figure 3.4.1.1, was located on the northwest corner of Santa Fe and PCH at a fast food restaurant's parking lot (Fast Food Site). Morning and afternoon data collected at the Fast Food Site were compared to each other along with available wind data. In addition, a rough estimate of truck counts traveling through the intersection during monitoring at the site was conducted via review of the video recording.

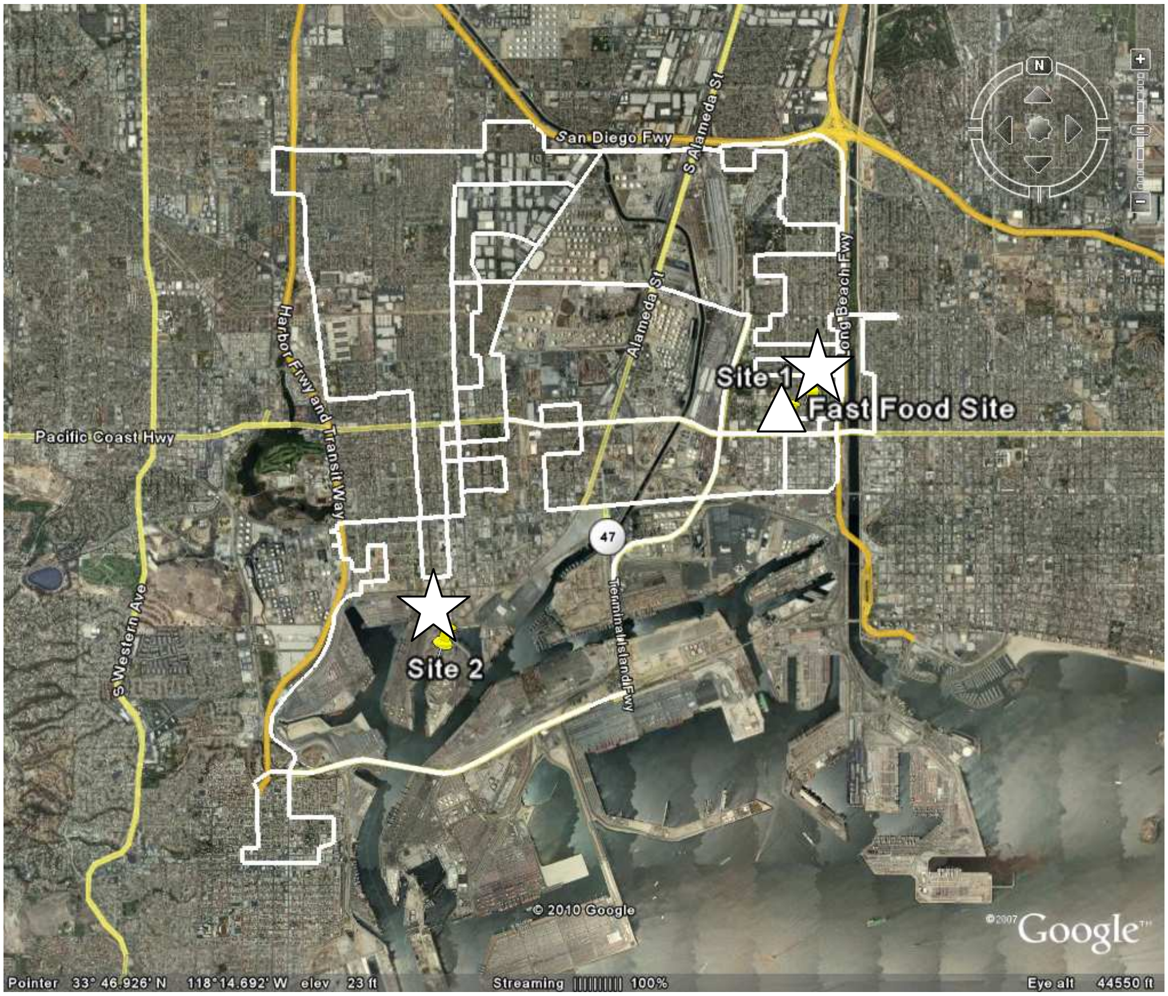

Figure 2.4.1.1. PFT and Residential fixed routes driven in winter and summer of 2007. White stars indicate select sites where meteorological data were collected; white triangle indicates a stationary monitoring site.

2.4.1.3 Impact Zone Designations

2.4.1.3.1 Freeway Impact Zone Designation

Locations less than 150 m away from a major line source were designated as impact zones; otherwise, adjacent locations greater than 150 m from a major line source were designated as "reference zones." This distance was based on recommendations from the California Air Resources Board (CARB) Air Quality and Land Use Handbook (CARB, 2005). Figure 3.4.1.2a shows a map indicating impact and reference zones near the I-710 freeway. The I-710 impact zone was defined as the area 150 m west of the freeway sound wall. The I-710 reference zone was defined as the interior residential section located immediately west of the I-710 impact zone and was bounded by Santa Fe Avenue (Santa Fe) and Fashion Avenue, about 750 m and 150 m to the west of the I-710 freeway, respectively. Both impact and reference zones were bound by 19th Street to the south and 25th Street to the north, 1200 m apart.

This residential area was an ideal location to isolate freeway impacts since vehicular traffic within the neighborhood at sampling times was minimal. However, impacts from individual vehicles were noted when relatively large increases in pollution concentrations (at least twice the observed background concentration) could be unambiguously linked to vehicles near the mobile platform by video; calculations were made both with and without these measurements.

2.4.1.3.2 Major Non-Freeway Arterial Impact Zone Designation

The major non-freeway arterials of interest for impact zone measurements were Pacific Coast Highway (PCH) and Anaheim Street (Anaheim); both are oriented east-west and heavily trafficked by HDDTs. Diesel truck counts by Houston et al. (2008) on PCH and Anaheim taken during the weekday were 148 and 170 per half hour, respectively, compared to fewer than 50 HDDTs per half hour counted at a nearby site dominated by gasoline vehicles. Arterial impact zones were defined as portions of the route on Santa Fe extending 150 m to the north and south of PCH and Anaheim. Arterial reference zones were defined as the portion of the route on Santa Fe occurring in the area outside the impact zone up to a distance of 600 m. Figure 3.4.1.2b shows arterial impact zones for PCH only. Impact zones on Anaheim were similarly arranged.

a. b.

Figure 2.4.1.2. (a) Map of designated freeway impact and reference zones. (b) Map of designated north and south impact zones near PCH.

2.4.1.4 Selection of Sampling Days

Five winter and four summer sampling days were selected for impact zone analysis: February 10, 13, 21, 23, 26; July 17, 25, 31; and August 7 (Table 3.4.1.2). These days were selected based on the highest consistency in wind direction to ensure differences between the impact and reference zones were as consistent as possible during the times of the measurements. In addition, one weekend sampling day (February 10) and one "after-rain" sampling day (February 23) were included in the winter analysis.

Although these days were selected for consistent wind direction, they were otherwise representative of all sampling days in other meteorological aspects. Table 3.4.1.1 shows for selected sampling days at Site 1, the mean wind speed and vector-average wind direction were between 1.4-1.7 m s^{-1} and 260-270 degrees, while mean wind speed and vector-average wind direction for all sampling days were very similar, between 1.4-1.8 m s^{-1} and 260-270 degrees. Note that these data reflect conditions observed during sampling times only (8:00 and 10:30, 14:30 and 17:00).

Daily meteorological conditions observed during winter and summer sampling were also representative of the seasonal average conditions. Table 3.4.1.1 also shows mean wind speed and direction for Site 1 compared to data collected by USC near Site 1, and mean high temperatures collected by NOAA at the Long Beach Airport between 1971-2000. These data show southwest winds predominate in the study area, with the higher wind speeds in the winter being due to the movement of cold fronts through the region.

3.4.1.5 Stationary Monitoring at Heavily-Impacted Intersections with a Mobile Platform

Due to the relatively high traffic density at intersections, and the frequency of high emissions from hard accelerations, stationary monitoring was conducted at several key intersections heavily impacted by HDDT traffic. Stationary sites were located within the 150 m arterial impact zone. These locations were frequently trafficked by pedestrians, persons waiting for buses, and persons frequenting fast food restaurants and gas stations. Monitoring was conducted 10 to 15 m from the nearest intersection corner at these locations for 5-10 minutes during morning and afternoon sampling. The video camera was pointed toward the intersection to capture HDDTs crossing through the intersection during each light cycle. One of the most impacted stationary sites, shown in Figure 3.4.1.2, was located on the northwest corner of Santa Fe and PCH at a fast food restaurant's parking lot (Fast Food Site). Morning and afternoon data collected at the Fast Food Site were compared to each other along with wind data collected by the mobile platform while parked. The wind sensor was mounted to the top of the mobile platform at a height of 2.5 m from the ground. In addition, a rough estimate of truck counts passing through the intersection during morning and afternoon sampling at the site was conducted.

Table 2.4.1.1. Meteorological data for winter and summer sampling seasons at two sites including annual average temperature from a third site. Mean wind speed (WS) and direction (WD) observed at Site 1 during select sampling days and all sampling days, are for the time periods 8:00 to 10:30, and 14:30 to 17:00. Seasonal averages are comprised of data from February 20-March 8 and July 17-August 1 of 2007.

Site	Parameter	Season: Winter	Season: Summer
Site 1, SCAQMD, Select Sampling Days	WS (m s^{-1})	1.7	1.4
	WD (deg)	260	270
Site 1, SCAQMD, All Sampling Days	WS (m s^{-1})	1.8	1.4
	WD (deg)	270	260
Site 1, SCAQMD, Seasonal Averages	WS (m s^{-1})	2.1	1.8
	WD (deg)	187	197
USC Site, Seasonal Averages	WS (m s^{-1})	1.9	1.3
	WD (deg)	227	184
	Temp (^{o}C)	14	22
	RH (%)	54	75
NOAA (Long Beach), 1971-2006, Annual Averages	Temp (^{o}C)	16	23

Table 2.4.1.2. Freeway impact zone/reference zone ratios for BC, PB-PAH, NO, UFP (CPC, Model 3007), and absolute differences in CO_2 concentrations. Notes: Meteorological data from Site 1. Values uncorrected for specific vehicle influences are shown in parentheses. For downwind categories: "No," "Sometimes," and "Yes" refer to impact zone being downwind 0%, <30%, and >30% of the time, respectively. An asterisk indicates UFP data from FMPS. (See Section 4.3 for more detail).

Date (2007)	Time of Day	Wind Speed (ms^{-1})	Downwind?	BC	PB-PAH	NO	UFP	ΔCO_2 (ppm)
17-Jul	AM	1.6	Yes	4.0	11.0	2.6 (3.4)	3.7	-1.4
	PM	2.9	No	1.5 (1.3)	0.8 (2.0)	0.4 (0.2)	1.1	-1.2
25-Jul	AM	1.9	Yes	2.2	5.6	2.3	2.0	10
	PM	2.5	No	1.2 (1.0)	1.1 (0.9)	0.9 (0.6)	0.8 (1.2)	-0.2
31-Jul	AM	1.7	Yes	3.9 (3.2)	7.4 (5.3)	7.5 (4.7)	2.9*	8
	PM	3.3	Yes	1.6	4.3	1.9	1.8*	2.5

7-Aug	AM	1.0	Yes	2.7	4.1	7.2	3.5	4.3
	PM	1.9	Yes	2.3	6.3	2.1	1.5	3.3
			Average "Yes"	2.8	6.4	4.2	2.6	4.5
			Average "No"	1.4	1.0	0.7	0.9	-0.7
10-Feb	AM	0.9	Sometimes	1.5	2.0	1.2	1.8	13
	PM	4.6	No	0.9	0.7	0.7	0.7	-1
13-Feb	AM	1.9	Sometimes	2.4	1.2	1.0	1.2	120
	PM	6.1	No	0.7	0.8	0.4	0.7	-13
21-Feb	AM	0.8	Sometimes	2.6 (1.7)	3.7	2.2	3.3	-13
	PM	2.8	No	0.6 (0.4)	1.6	0.7 (0.3)	1.2	-20
23-Feb	AM	3.4	No	5.0	0.7	0.6	1.0	8
	PM	3.9	No	1.5	0.6	0.6	0.7	-5
26-Feb	AM	0.6	Sometimes	3.0	2.3	2.9	1.7	46
	PM	3.1	No	1.0 (0.4)	1.5 (0.5)	1.6 (1.1)	1.0 (0.8)	-5
			Average "Sometimes"	2.4	2.3	1.8	2.0	41.5
			Average "No"	1.6	1.0	0.8	0.9	-6.0

2.4.2 Pre-sunrise Study in West Los Angeles

Zhu et al. (2002a, b) measured UFP, black carbon, and CO at various distances from two southern California freeways and demonstrated the existence of strong pollutant concentration gradients, with decreasing concentrations with increasing distance from the freeway during the day time and early evening. However, little or no information was available about pollutant concentrations in the vicinity of roadways during pre-sunrise hours prior to the present project. During this period, meteorological conditions, including low wind speeds, modest ambient air temperature, and possible temperature inversion, could result in no strong turbulent mixing in the lower space. In sequence, air pollutants will reside in the low space for longer time, resulting elevated pollutant concentrations in the vicinity of heavy traffic roadways.

In the present study, air pollutant concentrations were measured over a wide area on the south and north sides of the I-10 freeway in west Los Angeles, California, 1-2 hours before sunrise in the winter and summer seasons of 2008 using an electric vehicle mobile platform equipped with fast-response instruments. We observed a much wider area of impact downwind of the freeway than reported in previous daytime and evening studies, consistent with low wind speed, absence of turbulent mixing, and nocturnal radiation inversions. Our pre-sunrise results were also strikingly different from those we observed for the same route during the daytime.

2.4.2.1 Route Development

For pre-sunrise measurements, the mobile platform was driven on a fixed route over three days in the winter season and two days in the summer season of 2008. The route covered a total length of about 3,600 m approximately perpendicular to the I-10 freeway in Santa Monica, California (Figure 3.4.2.1). The solid line in Figure 1 shows the section of the route over which the mobile platform traveled about 8-10 times during each monitoring period, reaching about 1,200 m south of the freeway. The dashed line shows the extended section of the route, over which the mobile platform traveled 2-4

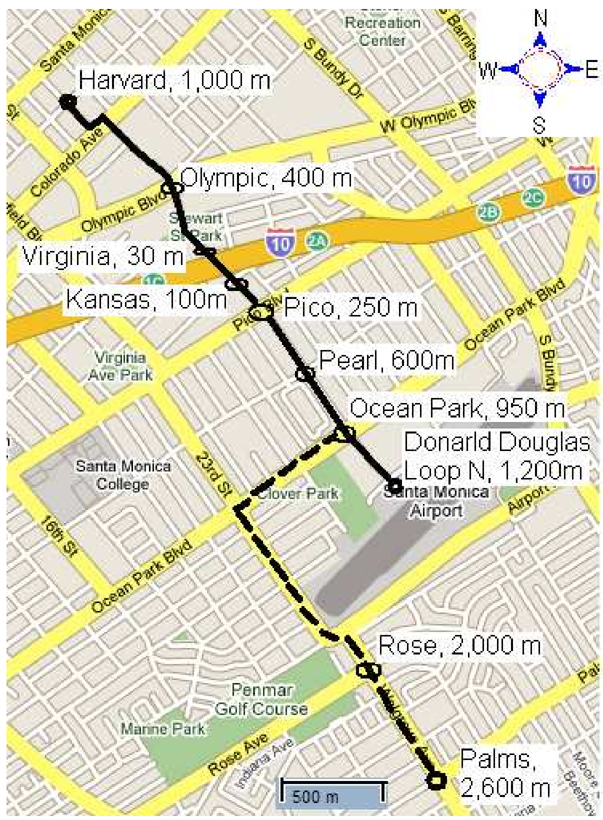

Figure 2.4.2.1. Pre-sunrise route. The solid line indicates the route 1,000 m and 1 200 m north and south of the I-10 freeway, respectively. The dashed line indicates the route extended to 2,600 m south of the I-10 freeway.

times during each monitoring period, reaching about 2 600 m south of the freeway. The pre-sunrise route crossed a number of local surface streets; these are shown in Figure 3.4.2.1 together with their normal distances to the freeway as measured from Google Map. The route was selected because it passed under the I-10 freeway, and because there was little traffic flow on the route itself and on the perpendicular surface streets (e.g. Olympic Blvd., Pico Blvd. etc.) during pre-sunrise hours. Hence, the majority of measurements were not significantly affected by local surface street traffic. Due to noise restrictions, the Santa Monica airport was not in operation during any of the pre-sunrise runs. The route also passed through a dense residential neighborhood where the elevated air pollutant concentrations have potentially significant exposure implications.

During sampling, the mobile platform was intentionally stopped to avoid localized impacts from individual vehicles whenever possible. During data reduction, pollutant concentration spikes, if verified from video tape to be caused by a nearby vehicle, were excluded from the analysis.

2.4.2.2 Real-time Traffic Flow

Table 3.4.2.1 shows the measurement periods for the pre-sunrise studies. Traffic volumes were collected or measured on the I-10 freeway, the pre-sunrise route itself, and the major surface streets transecting the pre-sunrise route. Real-time traffic flow on the freeway was obtained from the Freeway Performance Measurement System (PeMS) provided by the UC Berkeley Institute of Transportation. Sensors were located at the Dorchester Station, about 300 m from the intersection of the pre-sunrise route and the freeway. Since there were no ramps or exits between the Dorchester Station and our route, the PeMS data accurately represented the traffic flow on the I-10 freeway where our route passed under the freeway. Traffic flow on the pre-sunrise route itself was monitored and recorded by a Stalker Vision Digital System on the mobile platform. The recorded videos were replayed and vehicles on the pre-sunrise route were manually counted. Traffic flows on the major cross streets (e.g. Olympic Blvd., Pico Blvd., and Ocean Park Blvd.) were manually counted during the winter season on a weekday at times similar to when the pre-sunrise measurements were conducted.

Table 2.4.2.1. Measurement time periods for pre-sunrise studies

Date (2008)	Measurement period	Sunrise
March 7	6:20-7:50 [a]	7:14[a]
March 12	6:00-7:30	7:07
March 18	6:10-7:20	6:59
June 30	4:00-6:30	5:45
July 2	4:30-6:45	5:45

[a] Time corrected to Pacific Day Light Time (PDT), change from PST to PDT occurred on March, 9, 2008.

2.5 Data Analysis Methods

Data were adjusted for the various response times of the instruments on the mobile platform to synchronize the location represented by the measurements. BC, NO_x, CO, CO_2, and particulate data (UFP, CPC, and PM2.5 mass) were synchronized with particle-bound polycyclic hydrocarbon (PB-PAH) data measured by the PAS instrument, which had the fastest response time. NO, UFP, and PB-PAH were selected in the present study for detailed spatial analysis because of their rapid and large variation on and near roadways. The overall response time for the PAS instrument was determined by comparing the time of signal peaks in the PB-PAH time-series to the corresponding time of acceleration of a vehicle in front of our mobile platform (as recorded on videotape).

This time difference was less than 10-15 seconds and includes the transport time (typically a few seconds) for the plume from the emitting vehicle to reach the inlet of the sampling duct of the mobile platform. Given the short response times of our instruments and our driving speeds of 5 - 15 MPH, the spatial resolution of our mobile platform measurements was typically in the range of 25-75 m, with the finer spatial resolution (~25 m) near the locations where shaper pollutant concentrations occur such as edges of the freeway where we drove more slowly.

We generated a large database from the real-time data collection emphasis of this project. Time series analysis techniques as well as conventional statistical procedures were used to analyze the data set.

First, data were adjusted for the various response times of the different instruments on board the mobile platform. BC, NO_x VOC, CO, CO_2, and PM data were synchronized with PB-PAH data, the instrument with the fastest response time; PB-PAH is also an indicator compound for diesel particulate matter or DPM. This was accomplished by comparing the PAS time series with another instrument time series at the same time and adjusting the slower response instrument to match the PAS. Adjustments for all data series were made in this manner.

Next, corrections for instrument performance (instrument drift or bias) were made. These corrections were based on careful examination of time series to catch instrument drift or other potential issues that may require corrections. Third, data were checked for autocorrelation. If significant autocorrelation was observed, it was removed by using longer averages (10-15 seconds) for data analysis (Fruin et al., 2004). Fourth, data were checked for normality (i.e., normal frequency distribution) as this is an assumption for many statistical tests. If the data set was not normally distributed, steps were taken to transform the data (typically calculating the logarithm of the concentration). If, after transformation, the data set was not normal, non-parametric tests were used for our statistical analysis. Then, data were checked for equal variance, and hypotheses testing were conducted.

Data were grouped run-by-run and basic descriptive statistics developed, such as the mean and standard deviation of pollutant concentrations, were calculated for the grouped data. The data were grouped initially by sampling day, then subgroups based on location, time of day, and road type were created. Graphical representations such as boxplots were used to describe the contrast between groups and subgroups. Time series were an important graphical presentation form for our real-time data; and were supplemented with video analysis to describe what types of events lead to the concentrations observed.

Video tape records were used to correlate pollution concentrations with different sources (e.g. following a diesel truck) and determine road types and route segments on the route (e.g. residential versus arterial). In addition to road type, vehicle location, and presence of diesel vehicles, other information gathered from the video recordings include: time, presence of accelerating vehicles, trucks passing in cross traffic, truck density, traffic density (for freeways only), when the vehicle was stopped, land use, transcription of the audio recording and other observations.

Recording road types and location along the route is a key component to conduct hypothesis testing as it depends on correlating locations with concentrations and determining if concentrations between different locations are significantly different from each other.

A wide range of specific examples of the types of data analyses, and presentations of the data we utilized in the present study can be found in our final report for our earlier ARB-sponsored school bus project (Fitz et al. 2003).

3.0 CHARACTERIZATION OF NEAR-ROAD AIR POLLUTION IMPACTS DUE TO GOODS MOVEMENT IN DESIGNATED IMPACT ZONES

3.1 Introduction

Air quality close to and downwind of heavily-trafficked roadways includes localized high pollution concentrations and sharp concentration gradients such as measured by Zhu et al. (2002a, b) and Hitchins et al. (2000). These concentrations are critically important in determining human exposure at the individual and community levels as many people live and work near heavily-trafficked roadways. However, these localized high concentrations cannot be readily estimated by the current network of widely-spaced, fixed-site monitoring stations, even though many studies have shown persons living adjacent to sources like busy roadways exhibit significantly increased incidences of many adverse health effects (Brugge et al., 2007). These include increased risk of reduced lung function (Brunekreef et al. 1997), cancer (Knox and Gilman 1997; Pearson et al., 2000), respiratory symptoms (van Vliet et al. 1997; Venn et al. 2001; Janssen et al. 2003), asthma (Lin et al. 2002; McConnell et al., 2006), and mortality (Hoek et al. 2002).

The use of a mobile platform outfitted with real-time monitoring instruments provides the necessary temporal and spatial resolution to characterize pollution concentration gradients and on-road concentrations while traveling at normal vehicle speeds. Westerdahl et al. (2005) and Fruin et al. (2008) used such a mobile platform to demonstrate strong links between high on-road concentrations of pollutants like black carbon (BC) and ultrafine particles (UFP) and various measures of heavy-duty diesel truck (HDDT) traffic. A similar platform was utilized in the current study to characterize pollution concentrations and their gradients in locations impacted by goods movement traffic in the communities near the Ports of Los Angeles and Long Beach. Many other studies have demonstrated the usefulness of a mobile platform for determining the temporal and spatial distribution of pollutants in Europe (Bukowiecki et al. 2002a, b and 2003; Weijers et al. 2004; Pirjola et al. 2004 and 2006), China (Yao et al. 2005) and the United States (Kittelson et al. 2004a, b; Kolb et al., 2004; Unal et al. 2004; Isakov, Touma, and Khlystov, 2007; Baldauf et al. 2008).

Freeway and roadway impacts, especially those roadways heavily trafficked by HDDTs are a common urban problem in the United States. However, the tripling of goods movement at the Ports of Los Angeles (POLA) and Long Beach (POLB) over the past 20 years, with a similar increase predicted for the next decade, make current air quality impacts in this location particularly important to characterize and track over time. Up to 600 HDDTs per hour have been observed at various intersections in Wilmington and West Long Beach for several hours a day (Houston et al., 2008), and such emission sources provide the potential for high on-road and near-roadway exposures. The I-710 freeway averages over 1100 diesel trucks per hour (CalTrans, 2006) with peak hours having 2200 (Ntziachristos, 2007) to 2600 HDDTs (Zhu et al., 2002b).

While several studies such as Zhu et al. (2002a,b) have measured near-freeway gradients as a function of distance, this paper presents some of the first such measurements made on a large spatial scale during widely-varying wind directions and other meteorological conditions in two seasons, allowing the results to be generalized to other near-freeway and near-roadway situations. For example, near-freeway impacts were observed to be significant even when the fraction of actual time downwind was low; during times of variable wind direction; and across a full range of wind directions (from perpendicular to nearly parallel to the roadway).

3.2 Sampling Days

Of the 24 sampling days, 5 days were excluded from impact zone analysis (March 8, July 10, 13, 14, and August 9) because either adequate meteorological data were not available or only one half of the sampling day was completed. Sampling days included in the analysis covered both warm and cool seasons, a range of meteorological conditions, weekend days, and include one day before and after a rain event.

Table 4.2.1 shows meteorological observations by season for all selected sampling days at Site 1. The mean wind speed and vector-average wind direction was between 1.4-1.8 m s^{-1} and 260-270 degrees, respectively. Note that these data reflect conditions observed during sampling times only (8:00 to 10:30, 14:30 to 17:00). Daily meteorological conditions observed during winter and summer sampling were also representative of the seasonal average conditions. Table 4.2.1.1 shows mean wind speed and direction for Site 1 compared to data collected by USC near Site 1, and mean high temperatures collected by NOAA at the Long Beach Airport between 1971-2000. These data show southwest winds predominate in the study area, with the higher wind speeds in the winter being due to the movement of cold fronts through the region.

Table 2.4.2.1. Meteorological data for winter and summer sampling seasons at two sites including average daily maximum temperature from a third site. Mean wind speed (WS) and direction (WD) observed at Site 1 during all sampling days, are for the time periods 8:00 to 10:30, and 14:30 to 17:00. Seasonal averages are comprised of data from February 20-March 8 and July 17-August 1 of 2007.

		Season	
Site	Parameter	Winter	Summer
Site 1, SCAQMD, All Sampling Days	WS (m s^{-1})	1.8	1.4
	WD (deg)	270	260
Site 1, SCAQMD, Seasonal Averages	WS (m s^{-1})	2.1	1.8
	WD (deg)	187	197
USC Site*, Seasonal Averages	WS (m s^{-1})	1.9	1.3
	WD (deg)	227	184
	Temp (^{o}C)	14	22
	RH (%)	54	75
NOAA (KLGB) , 1971-2006, Annual Averages	Daily Max Temp (^{o}C)	16	23

*Next to Site 1 but 3.5 m lower

3.3 Results and Discussion

3.3.1 Meteorological Observations

Recent studies have shown the importance of meteorology on impacts in the near-road environment (Baldauf et al. 2008; Thoma et al. 2008). Wind direction and wind speed were especially important in affecting pollution impacts on near-roadway locations in the study area adjacent to the Ports. Wind patterns in this area are complex due to complex terrain and shoreline orientation in the region, and were often observed to vary significantly between sites for the same period.

These differences required obtaining wind data near where sampling occurred for accurate evaluation of wind effects. In this study we were able to obtain meteorological data from two nearby sites. The first site, a South Coast Air Quality Management District (SCAQMD) site, was located in West Long Beach near Santa Fe Avenue and PCH (Site 1, shown in Figure 3.4.1.1) collecting data in 2 minute averages. At Site 1, meteorological data were collected at a height of 8.5 m with a MetOne sonic wind sensor. Data from a site run by the National Oceanographic and Atmospheric Administration (NOAA), close to the ports (Site 2, shown in Figure 3.4.1.1), were utilized when data from Site 1 were unavailable (see Section 3.4.1.4 for more discussion). This was the case for sampling conducted on February 10 and 13.

Meteorological data collected by the University of Southern California (USC) (located next to Site 1, collecting data at a height of 5 m), and a NOAA site at the Long Beach Airport were also used to determine the representativeness of the meteorology during summer and winter sampling in 2007. The mobile platform also collected temperature, relative humidity, wind speed, and wind direction data when operating in stationary mode.

3.3.2 Pollutant Concentrations in the I-710 Freeway Impact Zone during Summer

Wind direction, and to a lesser extent, wind speed, were dominant drivers in determining the presence and extent of the I-710 freeway impact zone in all seasons, but effects were highest in the summer because wind direction was more consistent and contained easterly components from day to day compared to the rest of the year, especially in the morning. (Freeway impacts immediately to the east of the I-710 freeway may have been higher in the winter, but this location was inaccessible by the mobile platform.) Summer meteorology during sampling was characterized by southerly winds with an occasional easterly component in the morning, and stronger, more westerly winds in the afternoon. Despite atmospheric mixing height being higher in the summer compared to the winter, these wind conditions established a pattern of high morning pollution concentrations in impact zones during the summer, particularly in the morning. Figure 4.3.2.1 shows wind roses for morning and afternoon sampling times during the summer season, which include data from all selected summer days (9 days). On average, across all selected pollutants (BC, PB-PAH, NO, UFP), morning pollutant concentrations in impact zone were about 3 times higher compared to the reference zone. In the afternoon, pollutant concentrations in the impact zone were on average, 1.5 times higher compared to the reference zone. The lower ratio in the afternoon was attributed to a combination of changing wind direction, higher average wind speeds, and an increase in atmospheric mixing height. The magnitude of the effects observed in the impact zone varied from day to day with meteorological conditions. An example of observations from one day is shown in Figure 4.3.2.1. Note the scales for these boxplots have been selected to best visualize the distribution in the data.

Table 4.3.2.1 shows the ratios of impact zone-to-reference zone concentrations for each summer sampling day. These ratios of BC, PB-PAH, UFP and NO exhibited significant daily variation, but were routinely highly-elevated in the morning hours. Generally, when the impact zone was downwind of the I-710 freeway for any fraction of the time, impact ratios were greater than 2.0, and statistically significantly greater than when the impact zone was not downwind (Mann-Whitney, $p<0.05$). When the impact zone was upwind of the freeway, the impact ratio was close to 1.0. Table 4.3.1.1 also shows some ratios for individual pollutant measurements, particularly PB-PAHs, to be very high. For example, morning impact ratios for PB-PAH on July 17 and August 7 were unusually high compared to other pollutants and other days. These high ratios may have been due to relatively low background levels of PB-PAHs away from line sources and the resulting decreased precision of the measurements.

It is important to note the CO_2 concentrations shown here are the differences between concentrations observed in the impact zone and reference zone (as opposed to the ratio). With the exception of the morning of July 17, CO_2 concentrations were always higher in the impact zone than the reference zone when the impact zone was downwind of the I-710. In contrast, when the impact zone was upwind of the freeway (afternoons of July 17, 25, 27; August 2, 6), CO_2 concentrations were higher in the reference zone. CO_2 concentration differences between "yes" and "no" categories were statistically significant (Mann-Whitney, $p<0.05$). Higher CO_2 in the reference zone generally occurred during afternoon westerly winds and may reflect traffic emissions from Santa Fe, an arterial road immediately west of the reference zone with relatively little diesel vehicle traffic. During these times, the other pollutant impact ratios were close to 1.0.

Diurnal changes in HDDT and light duty traffic volumes on the I-710 freeway may also have affected diesel-related pollution concentrations in the impact zone as traffic volumes can change significantly from hour to hour. Chinkin et al. (2003) used weigh-in-motion sensors (year 2000 data) on the I-710 freeway in Long Beach to determine diurnal traffic patterns. Based on these data we estimated HDDT traffic volumes to be between 1500-1800 trucks per hour during morning sampling and 1200-1400 trucks per hour during afternoon sampling. For light duty vehicles we estimated 8500-10500 vehicles per hour in the morning and 11,500-12,000 vehicles per hour in the afternoon. Based on these estimations, the magnitude of these impacts in the morning versus afternoon may have been partly influenced by differences in truck traffic volumes.

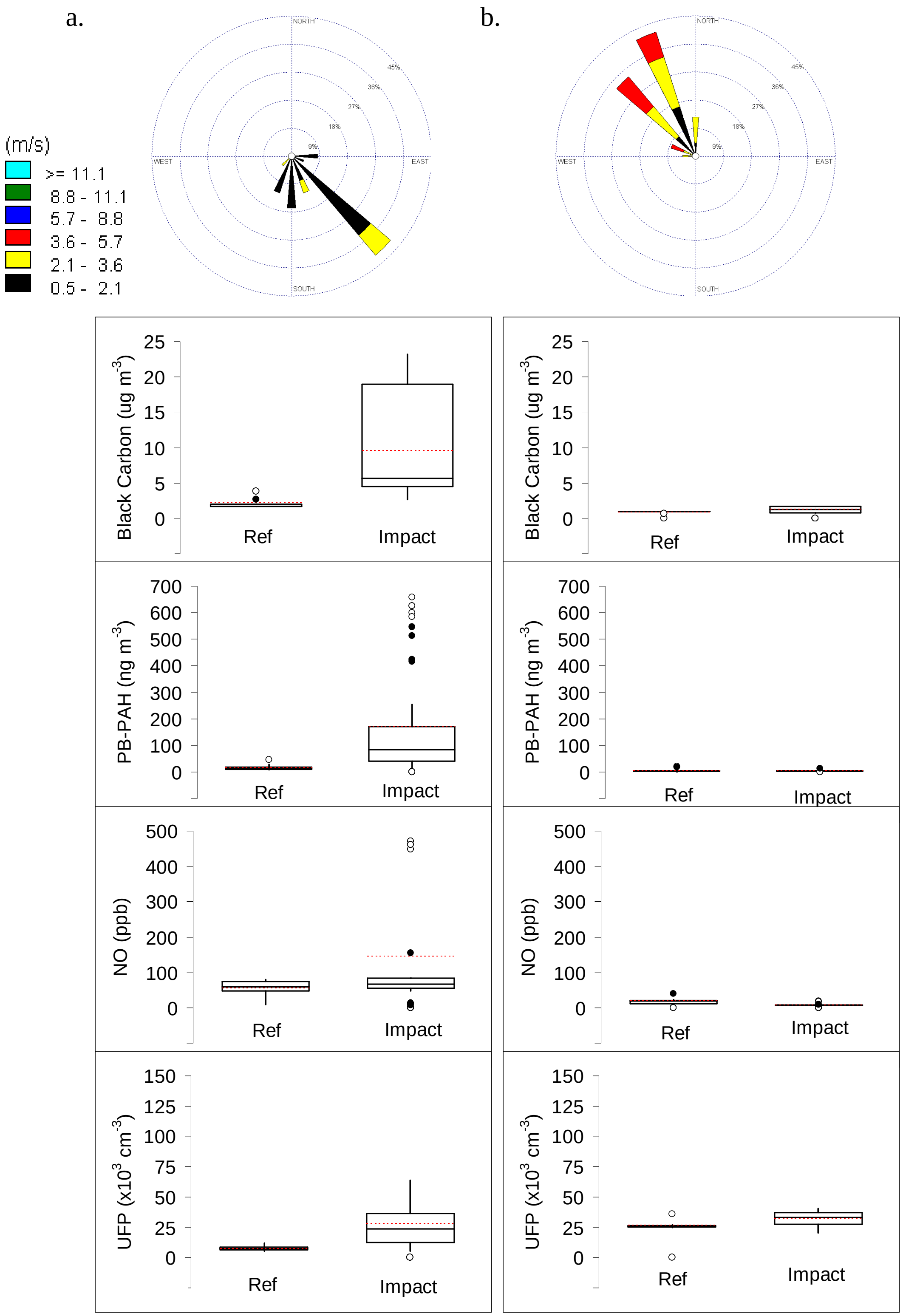

Figure 3.3.2.1. Morning (a) and afternoon (b) wind roses and corresponding BC, PB-PAH, NO and UFP concentrations in impact and reference zones (Ref) measured on July 17, 2007. Wind data from Site 1 were collected between 8:50-9:30 and 15:30-16:20.

Table 3.3.2.1. Summer impact zone/reference zone ratios for BC, PB-PAH, NO, UFP (CPC, Model 3007), and differences in CO_2 concentrations. Notes: For downwind categories: "No," "Sometimes," and "Yes" refer to impact zone being downwind 0%, <30%, and >30% of the time, respectively. An asterisk indicates UFP data from FMPS. Two asterisks indicates "Yes" values statistically significantly higher than "No" values (Mann-Whitney, $p<0.05$).

Date (2007)	Time of Day	Vector Averaged Wind Speed	Downwind?	BC	PB-PAH	UFP	NO	ΔCO_2 (ppm)
17-Jul	AM	1.6	Yes	4.0	9.0	3.7	3.4	-1.4
17-Jul	PM	2.9	No	1.6	0.8	1.2	0.6	-1.2
19-Jul	AM	6.1	Yes	2.8	4.3	2.0	2.0	12.0
19-Jul	PM	5.1	Yes	1.5	3.2	1.4	2.8	9.0
25-Jul	AM	1.9	Sometimes	2.2	5.7	2.0	2.5	10.0
25-Jul	PM	2.5	No	1.1	1.3	1.1	0.7	-5.1
27-Jul	AM	2.8	Yes	1.7	3.2	1.4	1.9	12.6
27-Jul	PM	6.5	No	1.1	0.7	1.1	0.9	-10.0
29-Jul	AM	4.8	Sometimes	0.8	5.2	2.5	2.0	1.2
29-Jul	PM	3.2	Yes	0.9	2.5	1.9	0.8	11.5
31-Jul	AM	1.7	Yes	2.8	4.7	2.6	4.8	7.9
31-Jul	PM	3.3	Yes	1.6	3.9	1.8*	2.1	2.5
2-Aug	AM	2.0	Sometimes	1.3	2.1	1.2	1.5	0.1
2-Aug	PM	7.9	No	0.9	0.6	1.1	0.5	-2.3
6-Aug	AM	2.9	Sometimes	2.4	5.5	2.1	3.7	7.3
6-Aug	PM	7.9	No	0.9	1.7	1.1	1.1	-0.3
7-Aug	AM	0.96	Yes	2.5	8.1	3.4	7.2	5.4
7-Aug	PM	1.9	Yes	2.2	6.4	1.5	2.1	3.7
			Average Yes	2.2**	5.0**	2.1**	3.0**	
			Average Sometimes	1.7	4.6**	2.0**	2.4**	
			Average No	1.1	1.0	1.1	0.8	

3.3.3 Pollutant Concentrations in I-710 Freeway Impact Zone in Winter

Winter meteorology was sometimes variable due to the low pressure fronts passing through the region, but typically consisted of stagnant mornings with strong temperature inversions and low mixing heights. Morning wind speeds averaged about 2.5 m s^{-1}; by the afternoon, wind speeds on averaged were 5.3 m s^{-1}, substantially higher. Greater variability in wind speed and direction during winter sampling resulted in impacts that were less consistent compared to the summer. Figure 4.3.3.1 shows the more modest impact zone effects typical of winter, as represented by black carbon. Although similar results were observed for PB-PAH and NO, UFP concentrations were observed to be about twice as high during winter mornings compared to summer mornings. These results are consistent with lower temperatures in winter favoring UFP formation (Kuhn et al., 2005).

Winter impact zone/reference zone ratios for all selected winter sampling days are shown in Table 4.3.3.1. Impact ratios were often elevated in the morning if any component of the wind was from the east, but overall these ratios were lower compared to the summer. The difference is greatest for when winds were "sometimes" easterly, from > 0 % to < 30%, with the numbers of pollutants showing statistically significantly increased impact ratios going from three in the summer (PB-PAH, UFP, and NO) to only one in the winter (UFP). Variable wind directions and light or calm wind speeds in the morning hours suggest that for some mornings, the impact zone may have been downwind of the freeway for only a short time; these two factors may have resulted in a lower impact zone concentration overall. In addition, the impact zone appeared to be downwind more frequently in the summer compared to the winter which would also contribute to elevated impact ratios in the summer.

CO_2 concentration differences between impact zones and reference zone were more variable in winter compared to summer. In general, concentrations in the impact zone were frequently lower than those observed in the reference zone, resulting in negative values in the last column of Table 4.3.3.1, but these still generally occurred during times of westerly winds and when diesel-related pollutant ratios were near 1.0. The exception was the morning of February 21.

Traditionally, port activity is lower in the winter (January-March) compared to the summer-fall period (August through October), during which goods movement from Asia is highest prior to the economically-busy holiday season. As a result, HDDT traffic is typically increased during the summer season (Houston et al., 2008), resulting in potentially higher near-roadway pollution concentrations in port adjacent neighborhoods compared to the winter. During 2007, summer port activity (as measured by number of containers) was about 13.5% higher compared to the winter (Port of Los Angeles 2007, Port of Long Beach 2007).

3.3.4 Ultrafine Particle Size Distributions in Impact Zones versus Reference Zones by Season

Figure 4.3.4.1 shows the differences in UFP size distributions for impact and reference zones for two winter and two summer sampling days. For impact zones, the winter UFP number concentrations were roughly five times higher across the size distribution compared to summer, although the summer size distributions showed a relatively larger fraction of particles >40 nm. In both seasons, reference zone UFP concentrations were markedly reduced, especially in the size range from 10 to 80 nm, giving flatter size distributions. Ntziachrisitos et al. (2007) found similar results next to the I-710 freeway (at a site north of the current study location) during the winter-spring season and found the size distribution was bimodal with a nucleation mode below 40-50 nm and a second lesser accumulation mode at 70-80 nm. The 10 and 100 nm peaks absent from summer size distributions were observed in both impact and reference zones, consistent with I-710 measurements made in the winter by Zhu et al. (2004).

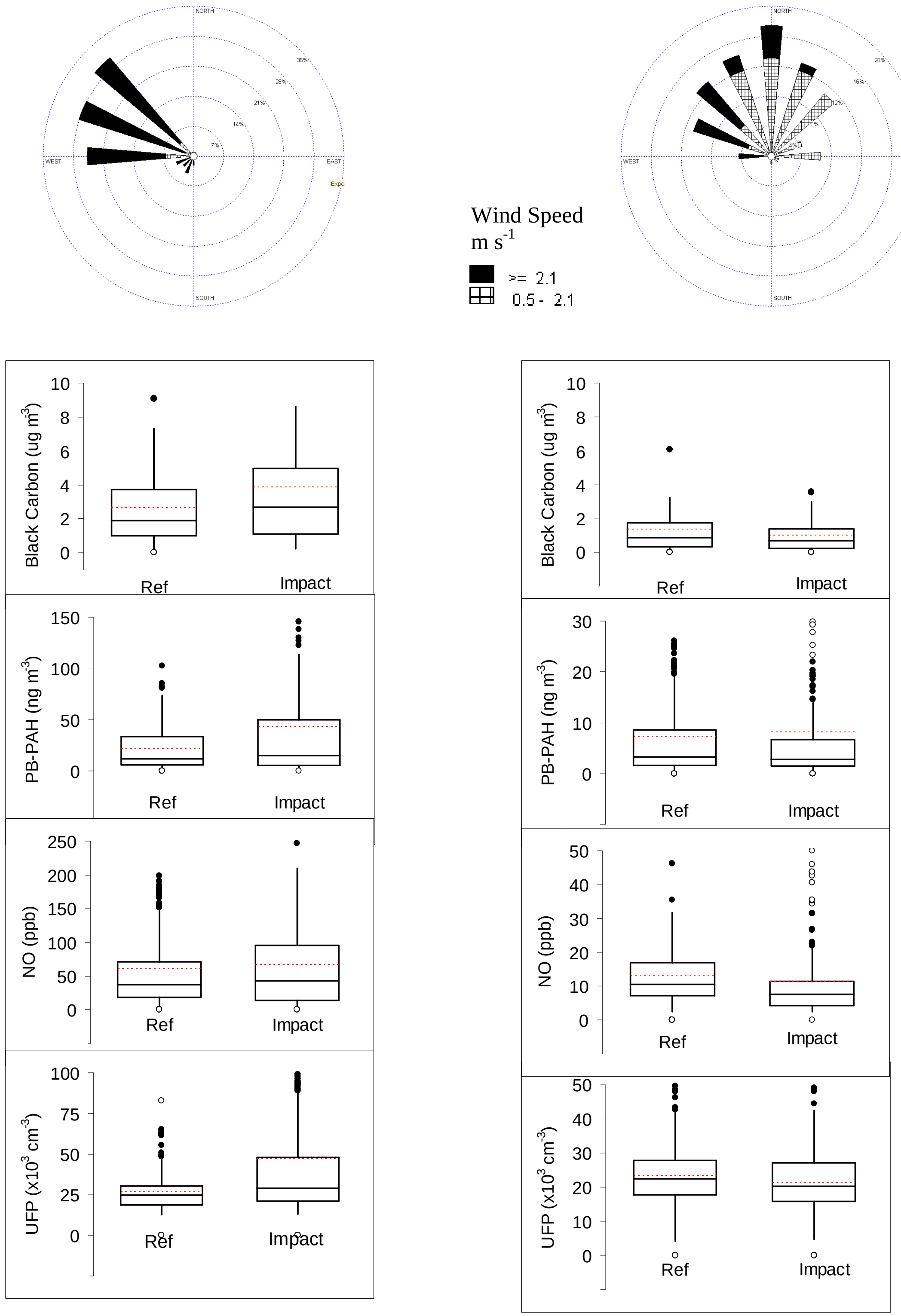

Figure 3.3.4.1. Morning (a) and afternoon (b) wind roses corresponding to boxplots for BC, PB-PAH, UFP and NO during the winter season. Wind rose data cover all selected sampling days during morning and afternoon sampling times.

Table 3.3.4.1. Winter impact zone/reference zone ratios for BC, PB-PAH, NO, UFP (CPC, Model 3007), and absolute differences in CO_2 concentrations. For downwind categories: "No," "Sometimes," and "Yes" refer to impact zone being downwind 0%, <30%, and >30% of the time, respectively. An asterisk indicates UFP data from FMPS. Two asterisks indicates "Yes" values statistically significantly higher than "No" values (Mann-Whitney, p<0.05).

Date (2007)	Time of Day	Vector Averaged Wind Speed	Downwind?	BC	PB-PAH	UFP	NO	ΔCO_2 (ppm)
10-Feb	AM	0.5	Sometimes	1.5	2.0	1.8	1.2	13
10-Feb	PM	4.9	No	0.9	0.8	0.6	0.7	-1.1
13-Feb	AM	2.5	No	2.4	0.9	1.2	1.2	120
13-Feb	PM	6.4	No	0.7	0.8	0.7	0.4	-13
20-Feb	AM	1.6	Yes	2.5	3.0	2.1	2.6	2.6
20-Feb	PM	1.4	Yes	1.2	5.5	2.1	3.3	3.0
21-Feb	AM	0.8	Yes	2.5	3.6	3.3	2.3	-7.7
21-Feb	PM	2.8	Sometimes	0.4	1.6	1.2	0.7	-9.5
23-Feb	AM	3.4	No	3.0	0.8	1.0	0.6	2.3
23-Feb	PM	3.9	No	1.3	0.9	0.7	0.7	-8.8
26-Feb	AM	0.7	Yes	2.2	2.4	2.0	2.8	46
26-Feb	PM	3.1	No	0.7	1.8	0.9	1.6	-4.7
28-Feb	AM	7	No	1.1	0.9	1.0	0.8	-14
28-Feb	PM	12	No	0.8	0.8	0.9	0.8	-3.5
1-Mar	AM	2.0	Yes	1.3	1.6	1.6*	1.4	43
1-Mar	PM	7.5	No	1.1	0.6	1.0*	1.1	-3.4
4-Mar	AM	3.7	Yes	0.8	0.9	1.0	1.0	-7.6
4-Mar	PM	6.1	No	0.6	0.7	1.0	1.1	-2.0
6-Mar	AM	3.3	Sometimes	1.1	1.1	1.0	1.0	-3.1
6-Mar	PM	4.8	Sometimes	0.9	0.6	1.0	0.7	-9.0
			Average Yes	1.7**	2.8**	2.0**	2.2**	
			Average Sometimes	1.0	1.3	1.3**	0.9	
			Average No	1.2	0.9	0.9	0.9	

The mean temperature and RH over the winter and summer sampling periods were 14° C, 22° C and 54%, 75%, respectively (Table 4.2.1.1). Jamriska et al. (2008) found temperature was a dominant factor in number concentration for nuclei mode particles. Cooler temperatures in the winter were likely to contribute to the increase in particle number concentration observed in Figure 4.3.4.1 a) and 4.3.4.1 b).

The effects of traffic volume as stated above may also have influenced the magnitude of pollution concentrations observed in the winter.

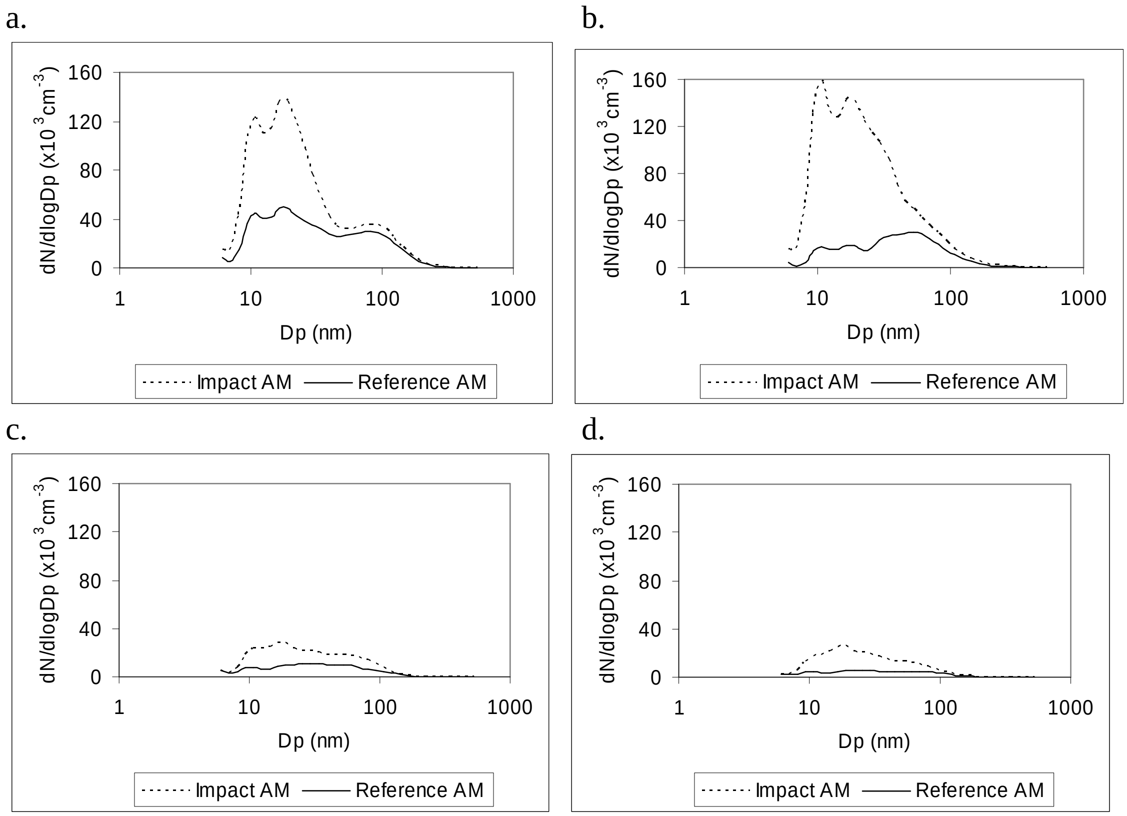

Figure 3.3.4.2 UFP size distributions collected on the mornings of (a) February 10, (b) February 21, (c) July 25, (d) August 7, 2007 comparing impact and reference zones.

3.3.5 Non-Freeway Arterial Impact Zones

Effects from arterial road vehicle emissions can also be quite high in impact zones when these locations are downwind of arterial roadways with HDDT traffic. This is illustrated in Figure 4.3.5.1a for the morning of February 13 when the northerly winds caused elevated pollution concentrations in impact zones to the south of PCH and Anaheim. Figure 4.3.5.1b shows the absence of effects from PCH and Anaheim when afternoon winds shifted to the west. Morning wind speed and direction were 2 m s^{-1} and from the north, while afternoon wind speed and direction were observed to be 6 m s^{-1} and from the west. The observed changes in wind speed and direction resulted in afternoon pollution concentrations that were generally 2 to 5 times lower than morning concentrations in both arterial impact and reference zones.

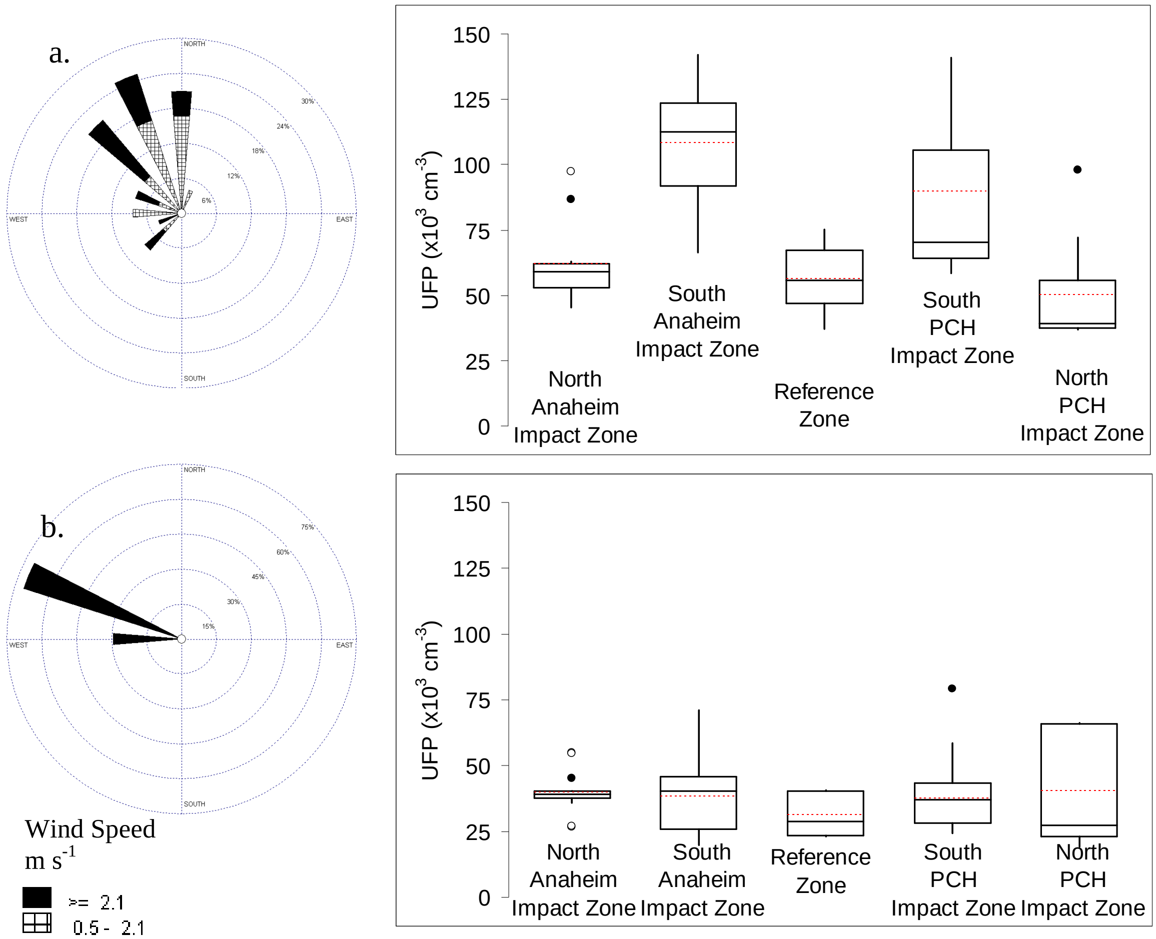

Figure 3.3.5.1. Morning (a) and afternoon (b) wind roses and particle number data collected February 13, 2007 from arterial impact and reference zones from PCH and Anaheim.

3.3.6 <u>Stationary Monitoring at a Heavily Impacted Intersection by the Mobile Platform</u>

High impacts near arterial roads were also observed during stationary sampling at intersections. Emissions at intersections were frequently high due to the confluence of roads, causing greater relative traffic density, accompanied by frequent hard accelerations. This was, shown in previous work to produce high, on-road concentrations (Fruin et al., 2008). The Fast Food Site, located on the northwest corner of PCH and Santa Fe, was one such intersection with frequent HDDT traffic. Rough diesel truck counts (including HDDT) over several days of winter and summer sampling at this intersection showed an average of about 11 diesel trucks per stop light change on PCH (about every 2 minutes) or, 340 trucks per hour. These counts agree well with those by Houston et al. (2008) made at the same location with weekday averages of 300 trucks per hour with a maximum of 350 trucks per hour. Truck counts at the Fast Food Site were also similar between winter and summer seasons and between morning and afternoon sampling.

As diurnal truck counts appeared to be steady across seasons and a given time of day, impacts from traffic on PCH were expected to be primarily dependent on wind direction. Table 4.3.6.1 shows pollution concentrations observed at the Fast Food Site based on wind direction (whether the site was downwind of PCH or not) and also includes mean pollutant data for freeway and arterial impact zones (a.m. only and included both winter and summer sampling days). Mean values for the Fast Food Site were based on the nine selected sampling days from summer and winter seasons. The largest impacts were observed when the Fast Food Site was directly downwind of PCH (when winds were from the southeast). The site was also downwind of the roadway (but not the intersection) when winds were from the northeast, but completely upwind of the intersection when winds were from the northwest. Consequently, the lowest pollution concentrations were observed during times of northwest winds.

Effects from the fast food site itself due to cooking or from other vehicles in the parking lot were not evident in these data and were assumed to be not significant compared to impacts from HDDTs on PCH. During the summer sampling, the site was dominated by southeast winds, while northwest and northeast winds were most frequent during winter sampling. As shown in Table 4.3.6.1 concentrations of pollutants at the Fast Food Site were several times higher compared to those concentrations observed in freeway and arterial impact zones, potentially increasing exposures for persons who spend a significant fraction of their day in similarly oriented businesses.

Table 3.3.6.1. Mean concentrations of BC, PB-PAH, UFP and NO measured at the Fast Food Site in the winter and summer of 2007 with corresponding wind direction measured with the mobile platform. Values are compared to mean AM and PM freeway and arterial impact zone concentrations.

	Downwind? (Wind Direction, degrees from N)				
	No (270-360)	Sometimes (0-90)	Often (90-180)	Freeway Impact Zone AM Average	Arterial Impact Zone AM Average
BC (ug m^{-3})	2.1	3.5	8.4	4.8	6.8
PB-PAH (ng m^{-3})	24	60	155	65	88
NO (ppb)	27	61	171	88	53
UFP ($x10^3$ cm^{-3})	33	43	45	38	99

3.4 Conclusion

The measurements presented here document how diesel-related pollutant concentrations such as BC, NO, UFP, and PB-PAHs are highly elevated within 150 m of freeways and arterial roads that have significant amounts of diesel traffic, resulting in large spatial areas being impacted. In the region of Los Angeles studied, diesel truck volumes were exceptionally high, up to six-hundred per hour for arterial roads (Houston et al., 2008) and over 2,000 per hour at peak hours for the I-710 freeway. However, since high impacts were found near these roadways whenever the wind placed a given area downwind of the roadway, we expect similar impacts to occur in rough proportion to diesel traffic volumes throughout Los Angeles and other urban areas (assuming temperature inversions and wind direction orientation to roadway are similar). This could translate to enhanced exposures for hundreds of thousands of persons that live, work, or use amenities near busy roadways, and significantly higher exposures than would be predicted by ambient measurements at non-impacted sites.

In general, we observed the highest roadway impacts in the morning hours, with two to five times higher concentrations within 150 m of the freeway, up to four times higher within 150 m of arterials, and five times higher within 10 to 15 m of intersections, when study areas were downwind of the roadway. Of the pollutants studied, we did not see significant impacts from gasoline-powered vehicles per se, but we did observe elevated CO_2 levels with elevated levels of diesel-related pollutants. In the case of the area near the Ports of Los Angeles and Long Beach, higher impacts were observed in the summer as study locations were more frequently downwind of major roadways compared to the winter, although we expect that decreased winter morning wind speeds and reduced mixing heights may have led to higher winter impacts in areas not measured in our study. One additional finding of importance was that impacts occurred whenever any significant fraction of the wind direction placed a given location downwind of a freeway or arterial road; the observance of high roadway impacts did not require steady nor consistent wind directions.

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4.0 MOBILE PLATFORM MEASUREMENTS IN WEST AND DOWNTOWN LOS ANGELES

4.1 Observation of a Wide Area of Air Pollutant Impact Downwind of a Freeway During Pre-Sunrise Hours

4.1.1 Introduction

Air quality in the vicinity of roadways can be seriously impacted by emissions from heavy traffic flows. As a result, high concentrations of air pollutants are frequently present in the vicinity of roadways and may result in adverse health effects. These include increased risk of reduced lung function (Brunekreef et al. 1997), cancer (Knox and Gilman 1997; Pearson et al. 2000), adverse respiratory symptoms (van Vliet et al. 1997; Venn et al. 2001; Janssen et al. 2003), asthma (Lin et al. 2002; McConnell et al., 2006), and mortality (Hoek et al. 2002).

Previous studies have shown elevated vehicle-related air pollutant concentrations and gradients downwind of roadways during daytime. Hitchins et al. (2000) measured concentrations of fine and ultra-fine particles (UFP) at a distance of 15 to 375 m from a major roadway during the daytime. They found concentrations decayed to about half of the peak value (at the closest point to the roadway) at approximately 100-150 m from the roadway on the normal downwind side. Particle concentrations were not affected by the roadway at a distance farther than 15 m on the normal upwind side, indicating a sharp gradient of fine and ultrafine particles. Similar studies were conducted by Zhu et al (2002a, b), who measured ultrafine particles, CO, and black carbon (BC) along the upwind (200 m) and downwind (300 m) sides of a freeway in Los Angeles during the daytime. Peak concentrations were observed immediately adjacent to the freeway, with concentrations of air pollutants returning to upwind background levels about 300 m downwind of the freeway.

The few near-roadway studies conducted at night indicated larger areas of impact than during daytime. UFP concentrations at night were reported by Zhu et al (2006), who conducted measurements upwind (300 m) and downwind (500 m) of a freeway from 22:30 - 04:00. Although traffic volumes were much lower at night (about 25% of peak) particle number concentrations were about 80% higher 30 m downwind of the freeway compared with the day, with UFP concentrations of ~50,000 cm^{-3} about 500 m downwind of I-405, a major Los Angeles freeway during the night. Fruin and Isakov (2006) measured UFP concentrations in Sacramento, California, near the I-50 Freeway between 23:00 and 01:00 and found 30-80% of maximum centerline concentrations (measured on a freeway overpass) 800 m downwind.

In the present study, the use of a full-size, motorized mobile platform (MP) allowed more pollutants to be measured than previous nighttime studies and with improved spatial and temporal resolution. While traveling at normal vehicle speeds, an instrumented mobile platform allows measurements over a greater distances and in shorter times (Bukowiecki et al. 2002a, b; 2003; Canagaratna et al. 2004; Kittelson et al. 2004a, b; Khlystov and Ma 2006; Kolb et al. 2004; Pirjola et al. 2004, 2006; Unal et al. 2004; Weijers et al. 2004; Westerdahl et al. 2005; Yao et al. 2005; Isakov et al. 2007; Baldauf et al. 2008; Fruin et al. 2008). However, to date, such studies have focused almost entirely on daytime and evening periods.

In the present study, air pollutant concentrations were measured over a wide area on the south and north sides of the I-10 freeway in west Los Angeles, California, 1-2 hours before sunrise in the winter and summer seasons of 2008 using an electric vehicle mobile platform equipped with fast-response instruments. We observed a much wider area of impact downwind of the freeway than reported in previous daytime and evening studies, consistent with low wind speed, absence of turbulent mixing, and nocturnal radiation inversions. Our pre-sunrise results were also strikingly different from those we observed for the same route during the daytime. Our observation of a wide area of impact during pre-sunrise hours, up to about 600 m upwind and 2,000 m downwind, has significant implications for exposures in residential neighborhoods adjacent to major roadways.

4.1.2 Results and Discussion

4.1.2.1 Real-time Traffic Flow

Traffic flows were collected or measured on the I-10 freeway, the pre-sunrise route itself, and the major surface streets transecting the pre-sunrise route. Real-time traffic flow on the freeway was obtained from the Freeway Performance Measurement System (PeMS) provided by the UC Berkeley Institute of Transportation. Sensors were located at the Dorchester Station, about 300 m from the intersection of the pre-sunrise route and the freeway. Since there were no ramps or exits between the Dorchester Station and our route, the PeMS data accurately represented the traffic flow on the I-10 freeway where our route passed under the freeway. Traffic flow on the pre-sunrise route itself was monitored and recorded by a Stalker Vision Digital System on the mobile platform. The recorded videos were replayed and vehicles on the pre-sunrise route were manually counted. Traffic flows on the major cross streets (e.g. Olympic Blvd., Pico Blvd., and Ocean Park Blvd.) were manually counted during the winter season on a weekday at times similar to when the pre-sunrise measurements were conducted.

4.1.2.2 Meteorological Data

Meteorological conditions, including atmospheric stability, temperature, relative humidity, wind speed and wind direction, play an important role in determining air pollutant concentrations and gradients along and downwind of roadways. During each run, the mobile platform was periodically stopped at locations along the pre-sunrise route to obtain wind data from on-board instruments (Table 5.1.2.1). These data were compared with the measurements from the Santa Monica Airport (SMA) located about 1 500 m downwind of the I-10 freeway and in the immediate vicinity of the route. Both the averaged wind speeds measured by the mobile platform and by the SMA were quite low during pre-sunrise hours, in a range of 0-1.0 m/s and the averaged difference between the two measurements was about 0.3 m/s. Temperature and relative humidity were obtained from SMA data.

Date	Measurement period	Sunrise	Atmospheric Stability from LAX Profiler data	Wind Speed [a] (m/s)		Wind Direction [a] (°)		Temperature (°C)	Relative Humidity (%)
				MP	SMA	MP	SMA	SMA	SMA
March 7	6:20-7:50 [b]	7:14 [b]	N.D. [c]	0.9	1.0	13	5	11	79
March 12	6:00-7:30	7:07	Surface inversion to 250-300 m	1.0	1.0	53	20	13	66
March 18	6:10-7:20	6:59	Surface inversion to 190 m	0.8	1.0	6	45	9	61
June 30	4:00-6:30	5:45	Stable to 190 m, inversion above	0.7	0.0	288	0	17	87
July 2	4:30-6:45	5:45	Stable to 260 m, inversion above	0.7	1.0	315	340	17	84

Table 4.1.2.1. Meteorological conditions during pre-sunrise sampling runs of the mobile platform (2008).

[a] Averaged values for the measured period.
[b] Time corrected to Pacific Day Light Time (PDT); change from PST to PDT occurred on March, 9, 2008.
[c] Profiler came online the following evening. The following night (3/8) experienced a surface-based inversion for the entire night.

Figure 5.1.2.1 shows the wind roses and vector-averaged wind direction for five days, March 7, 12, 18, June 30, and July 2, from data collected by instruments on the mobile platform. Wind speeds were low during the pre-sunrise hours, with monitoring-period averages ranging from 0.0 to 1.0 m/s. The averaged wind directions measured by the mobile platform indicated a predominant direction of N/NE/NW during the pre-sunrise runs, which agreed reasonably well with airport wind direction data for the same period. For this predominant wind direction, the north side of the I-10 freeway was upwind; the south side downwind. Although having a predominant direction from north, the wind was not completely perpendicular to the I-10 freeway. Hence, the distances pollutants traveled from the freeway to various locations along the route, including the major cross surface streets, were generally longer than indicated by distances shown in Figure 3.4.2.1. For example, the straight perpendicular distance of Ocean Park Blvd. to the I-10 freeway is ~ 950 m, whereas for the averaged wind direction of 25^{o} for the pre-sunrise run, the distance pollutants traveled was ~1,050 m. However, due to the variability of meteorological conditions, the perpendicular distances were used to indicate impact distances in the present study.

While detailed thermal structure data for the lowest layers of the atmosphere in the area of our pre-sunrise route were not available, the available data indicate the days sampled had stable (i.e., vertical) temperature profiles or strong nocturnal radiation inversions in the hours before sunrise. Data recorded at the Santa Monica Airport indicated the nights on which sampling took place were clear up to at least 3,000 m, and had either offshore flow or a weak land breeze, also consistent with clear skies; clear skies are conducive to the formation of nocturnal surface inversions due to the ground and the air near it rapidly losing heat under the clear skies.

Data collected by the South Coast Air Management District (SCAQMD) at the Los Angeles Airport (LAX), ~ 8 km south of pre-sunrise route, were also consistent with an inversion or stable conditions at the surface. On 3/10 and 3/18, the data showed temperature inversions from the lower edge of the measurements at 130 m up to 190 m or more, respectively. On 6/30 and 7/2, the profiles were stable from 130 to 190 or 260 m, respectively, with capping inversion layers above. Wind speeds during the pre-sunrise hours were too low to create appreciable vertical mixing in the presence of these temperature profiles, and the shallow mixed layer was likely thinner in March than in June/July.

4.1.2.3 Observation of a Wide Impact Area Downwind of the Freeway During Pre-sunrise Hours

As shown in Figure 5.1.3.1, a wide impact area of elevated UFP concentrations, more than 2,000 m downwind and 600 m upwind of the I-10 freeway, was observed during the pre-sunrise hours on the monitoring days in the two seasons. In this wide impact area, elevated UFP concentration extended beyond Donald Douglas Loop N located on the south side and 1,200 m downwind of the freeway (Figure 5.2.3.1). Here, 1,200 m downwind, the average UFP concentrations during the winter sampling hours, typically 06:00-07:30, were as high as ~ 40,000 cm^{-3}. Only at a downwind distance of about 2,600 m (Palms Blvd.), did the UFP concentration drop to ~15,000 cm^{-3}, comparable to the upwind background level.

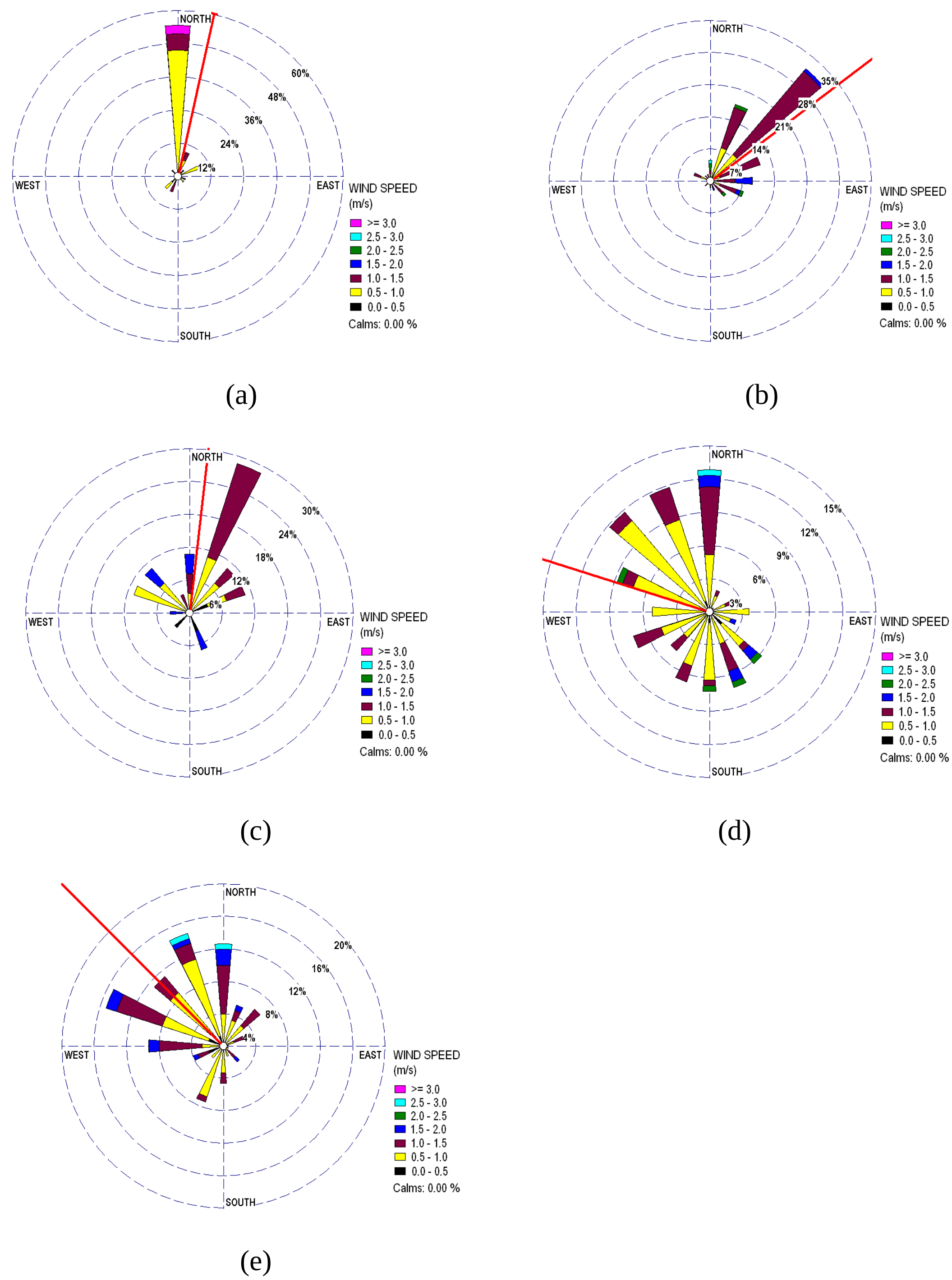


Figure 4.1.2.1. Wind roses for pre-sunrise sampling hours. (a) March 7; (b) March 12; (c) March 18; (d) June 30; (e) July 2. The thin line in each wind rose indicates vector-averaged wind direction.

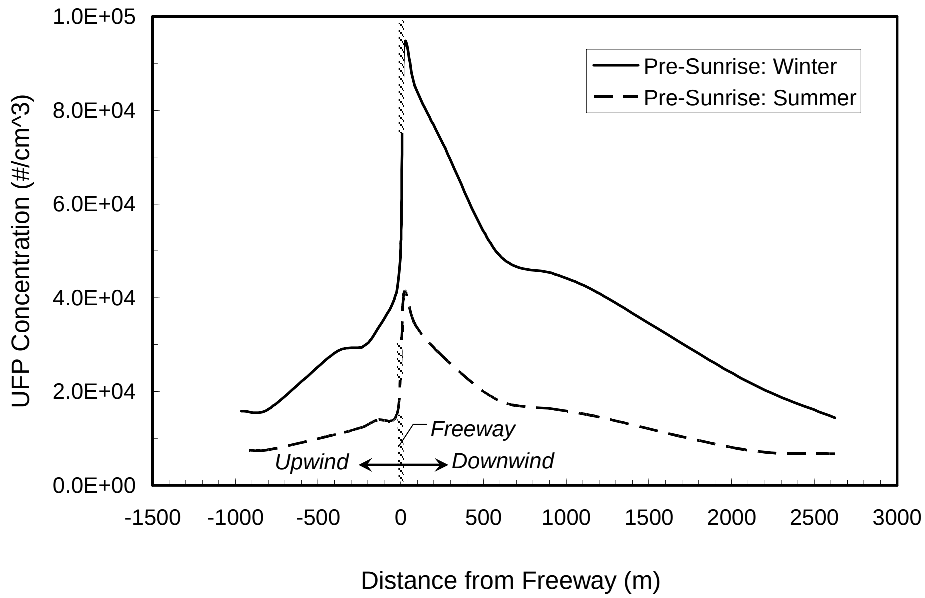


Figure 4.1.2.2. Ultrafine particle concentrations and gradients along the pre-sunrise route. Positive distances are downwind and negative distances upwind from the I-10 freeway. Multiple traverses of the route were made during each PSR monitoring period and in each run measurements were made continuously up to the edges of the freeway.

In the winter season, the peak UFP concentration was approximately 95,000 cm^{-3} a few tens of meters downwind of the freeway. Upwind, the concentration dropped sharply to around 40,000 cm^{-3} 30 m upwind (Virginia Avenue) and returned to background levels of ~15,000 cm^{-3} at ~ 800 m on the upwind side, creating a moderate upwind gradient north of the I-10 freeway (Figure 5.1.2.2). Interestingly, the upwind impact distance during the pre-sunrise hours, ~ 600 m, was far greater than that of ~15 m observed during the day by Hitchins et al (2000) and also greater than that measured by Zhu et al (2002b). This may be caused by the occasionally variable wind direction during the pre-sunrise hours for which the nominal upwind side of the I-10 freeway could temporarily become downwind. These occasional impacts on the nominal upwind side of the freeway appear to have had substantial influence on the averaged upwind UFP concentrations due to their otherwise low levels.

As seen in Figure 5.1.3.1, the UFP concentration also decreased on the downwind side, but much more slowly than on the upwind side. At a downwind distance of about 600 m from the freeway, UFP concentrations during winter were about twice those on the upwind side (50,000 cm^{-3} vs. 22,000 cm^{-3}). Even 950 m downwind, at the intersection of Ocean Park Blvd., the UFP concentration remained as high as 45,000 cm^{-3}, higher than at 30 m upwind. These pronounced differences in gradients of UFP concentrations resulted in strong contrasts between the upwind and downwind sides of the I-10 freeway during pre-sunrise hours (Figure 5.1.3.1).

As shown in Figure 5.1.3.2, NO and PB-PAH exhibited concentration gradients similar to UFP along the route during the pre-sunrise hours. Peak concentrations of NO and PB-PAH (on the downwind side) were about 165 ppb and 55 ng m^{-3}, respectively, in the winter season. Upwind, NO and PB-PAH concentrations dropped rapidly to 70 ppb and 30 ng m^{-3}, respectively, at a distance of about 150 m. In contrast, on the downwind side, NO and PB-PAH concentrations of 70 ppb and 30 ng m^{-3}, respectively, extended to a distance of about 1,200 m from the freeway (NO and PB-PAH data were unavailable for summer measurement due to instrument problems during the pre-sunrise runs).

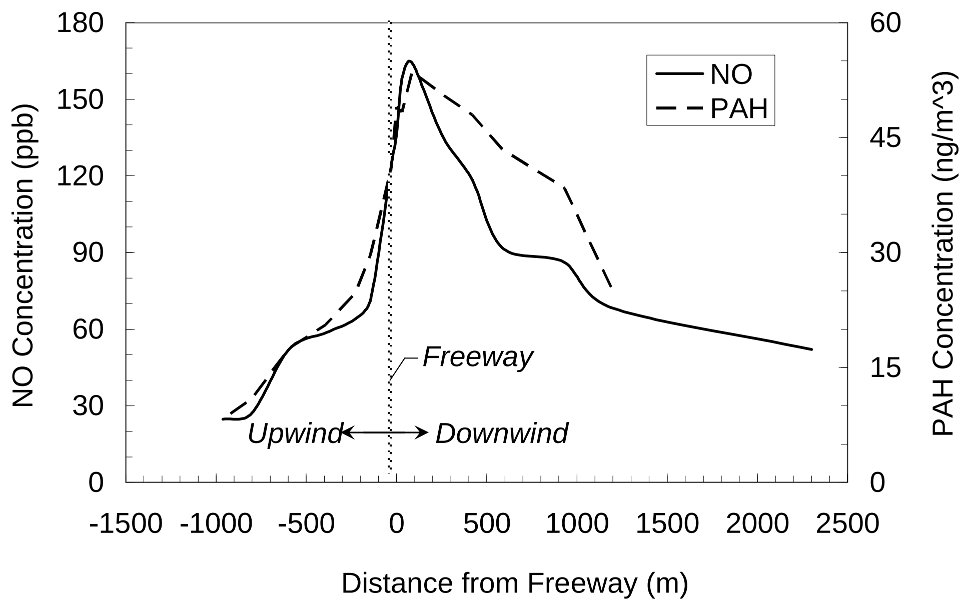


Figure 4.1.2.3. Average NO and PB-PAH concentrations and gradients, along the pre-sunrise route in the winter season. Positive distances are downwind and negative distances upwind from the I-10 freeway.

Figure 5.1.3.3 shows normalized UFP concentrations on the two sides of I-10 freeway during the pre-sunrise hours in the winter and summer seasons. UFP concentrations were normalized for each complete run traveled on our route, and then averaged together for all the runs for each season. While there was little or no traffic on our route during the pre-sunrise hours, vehicle counts on the same route during the day were much higher and emissions from these vehicles significantly and frequently affected measurements by the mobile platform. Moreover, the pre-sunrise route was only driven once in the morning after sunrise and once in the afternoon, in contrast to multiple times in the pre-sunrise period. For both of these reasons, comparison between pre-sunrise and morning/afternoon measurements on the pre-sunrise route are not meaningful. Instead, we show normalized data from Zhu et al. (2002b), which were not affected by local traffic, to compare with our pre-sunrise measurements.

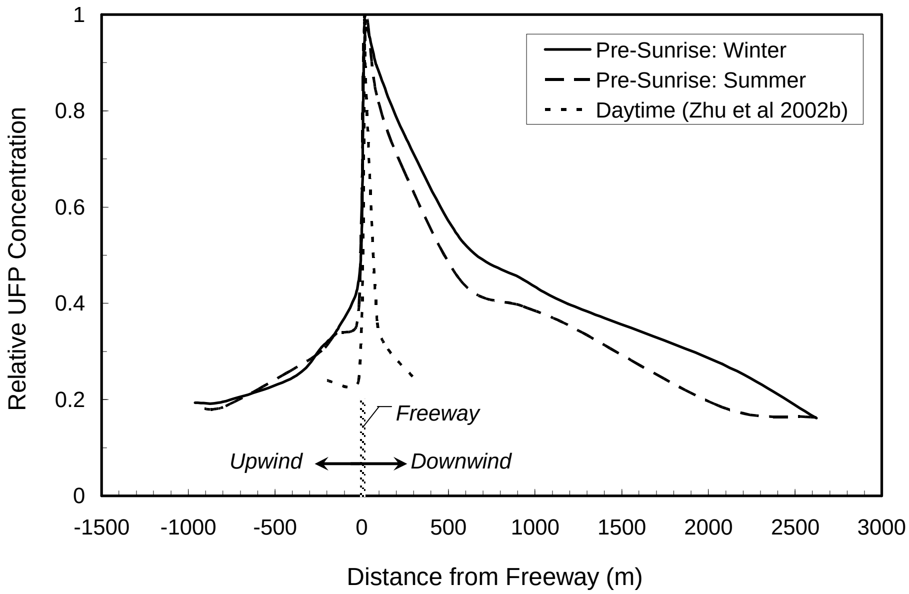


Figure 4.1.2.4. Relative averaged UFP concentrations and gradients along the pre-sunrise route by season and compared with Zhu et al (2002b). Positive distances are downwind and negative upwind from the I-10 freeway. Data were acquired continuously for pre-sunrise measurements, up to the edges of the freeway.

As Figure 5.1.3.3 illustrates, pre-sunrise UFP concentration gradients in the present study exhibited very different behavior than the typical narrow daytime UFP gradients measured by Zhu et al. (2002a, b). In our pre-sunrise measurements, UFP concentrations remained elevated above the background level up to ~ 600 m upwind of the freeway versus only ~17 m upwind for the Zhu et al. (2002b) daytime measurements. On the downwind side in the Zhu et al. (2002b) measurements, UFP concentrations dropped to about 25% of the peak concentration 300 m downwind of the freeway during the day, but in the present study, in strong contrast, the UFP concentrations remained about 40% of the peak as much as 1 200 m downwind of the freeway, and was above background levels out to ~2,000 m during the pre-sunrise hours.

To quantify these differences in UFP concentrations an equation of the form $C = a + e^{-bx}$ was used to fit our observed relative UFP concentrations downwind of the I-10 freeway during pre-sunrise hours, as well as the daytime data reported by Zhu et al. (2002b). As seen in Figure 5.2.3.4, the decay constant is a factor of five higher for the daytime vs. the pre-sunrise period, with values of b of 0.0098 and 0.0018, respectively.

Pre-sunrise relative UPF concentrations exhibited similar trends in both winter and summer (Figure 5.1.3.3). Although UFP concentrations in the summer were about 40% those in the winter (due to lower traffic flows on the I-10 freeway, as discussed below), the similar trends in relative UFP concentration imply similar UFP propagation during the pre-sunrise hours in the two seasons although meteorological conditions were somewhat different.

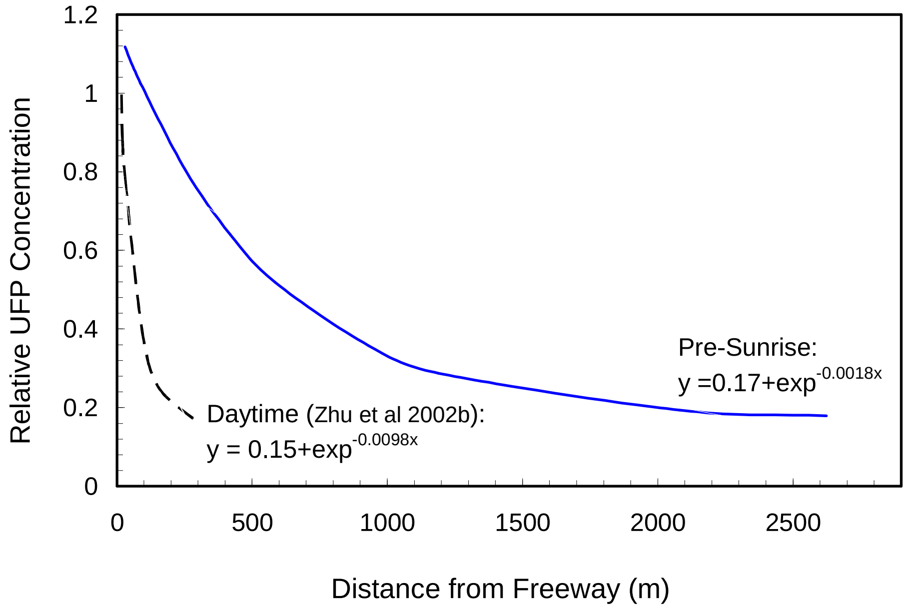
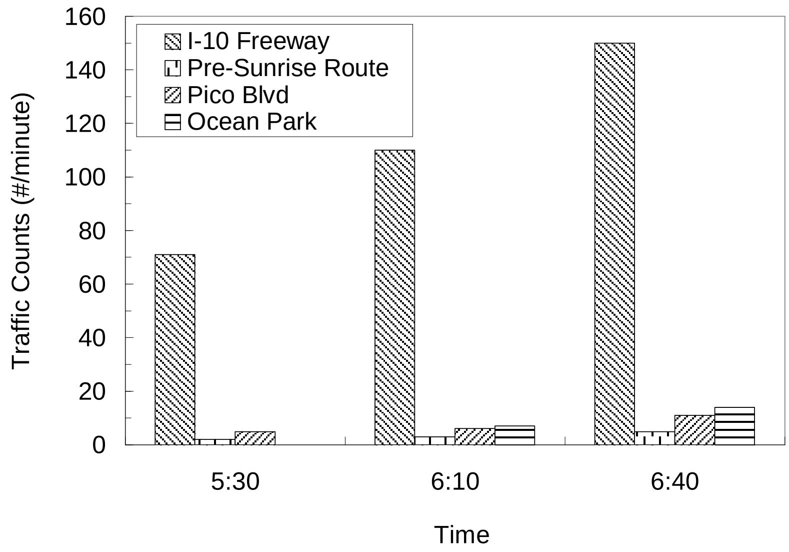


Figure 4.1.2.5. Exponential fits to the downwind relative UFP concentrations with distance from the I-10 freeway during pre-sunrise hours, compared with fit to daytime data downwind of the I-405 freeway by Zhu et al. (2002b). Data were acquired continuously for pre-sunrise measurements, up to the edges of the freeway.

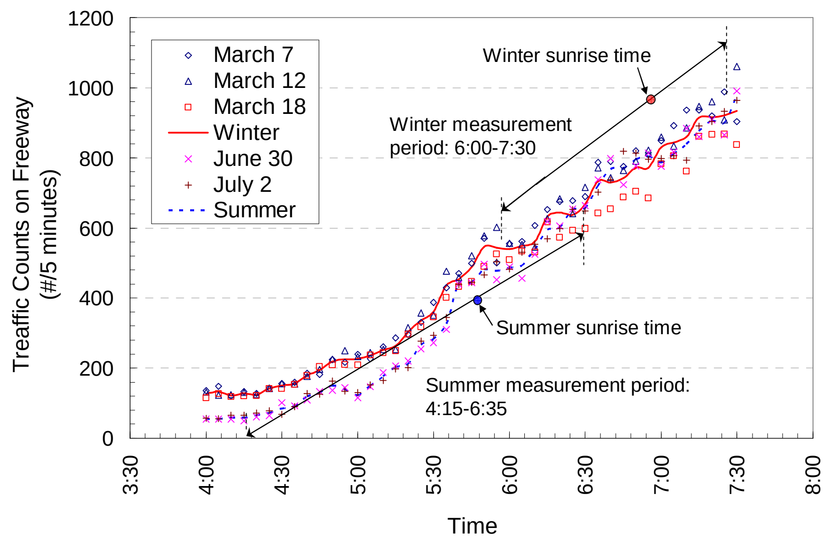
4.1.2.4 <u>Correlation of pollutant concentrations with traffic counts on I-10 freeway</u>

PeMS data showed a similar diurnal traffic pattern on the I-10 freeway on different weekdays during the pre-sunrise hours in both winter and summer (Figure 5.1.4.1b). Traffic counts on the freeway exhibited an approximately linear increase with the time (between 5:00 and 7:30 am). However, during 04:00 – 05:30 (when summer measurements were conducted) traffic counts were lower in summer than in winter. We attribute part of the lower traffic counts in summer to most schools being closed and vacation season in summer, as well as the dramatic increase in gasoline prices between March and July 2008, resulting in a significant overall reduction in vehicle miles traveled. Also, sunrise was about one hour and fifteen minutes earlier in summer (~ 05:45) than in winter (~ 07:00), which required an earlier measurement period in summer (~ 04:15 – 06:30) compared to winter (~ 06:00 – 07:30), and corresponds to much lower overall traffic counts during the pre-sunrise measurement periods in summer (all times shown are PDT).

During the measurement period in winter, traffic counts on the freeway increased from ~ 530 to ~ 900 vehicles per 5 minutes, while in summer counts increased from ~ 60 to ~ 620 vehicles per 5 minutes. Assuming a linear increase of traffic counts with time, the average traffic counts during the pre-sunrise measurements periods, winter versus



(a)



(b)

Figure 4.1.2.6. (a) Comparison of traffic volumes on the I-10 freeway, pre-sunrise route, Pico Blvd., and Ocean Park Blvd. during pre-sunrise hours on a typical weekday; (b) Traffic counts on the I-10 freeway during pre-sunrise measurements; solid line represents averaged count of the three days in the winter season, and dashed line for two days in the summer season. Sunrise times shown here were averaged for each season.

summer, were ~ 715 vs. 340 vehicles per 5 minutes, resulting a ratio of ~2.1. This ratio of seasonal traffic counts compares well with the ratio of the UFP concentrations measured in the winter vs. summer of ~ 2.2-3.0, depending on distance from the freeway (Figure 5.1.3.1). It should be noted that the sunrise times during the winter (March) measurements, because they occurred just after the switch to Pacific Daylight Time (PDT), were close to the latest annual (local) sunrise times, and thus may represent roughly the upper limit for the freeway impact throughout the year.

We attribute the relatively high pollutant concentrations we observed downwind of the I-10 freeway during pre-sunrise hours to emissions of vehicles traveling on the I-10 freeway, combined with strong inhibition of vertical mixing due to stable or inverted temperature profiles near the surface. Figure 5.1.4.2 shows the UFP and NO concentrations measured at Ocean Park Blvd., ~ 950 m downwind, vs. the traffic counts on the freeway during the pre-sunrise hours on three mornings of the pre-sunrise runs in the winter season. Both the freeway traffic counts (Figure 5.1.4.1b) and pollutant concentrations increased rapidly during the pre-sunrise hours, and exhibited a strong correlation with each other. For UFP, the values of squared Pearson correlation coefficients (r^2) were above 0.90 and for NO, above 0.77 (nitric oxide data were unavailable for summer measurements due to instrument problems during the pre-sunrise runs). Strong correlations at other distances from the freeway were also found between UFP concentrations and traffic counts on the freeway. For example, the correlation coefficients, r^2 for UFP measured at Pearl St for three winter sampling days were above 0.85.

Based on our video tape observations and the traffic counts we conducted on surface streets, as well as the strong correlations presented in Figure 5.2.4.2, we believe the measured concentrations of air pollutants during the pre-sunrise hours were predominantly determined by the traffic counts on the I-10 freeway, and that the impact of local surface street traffic was minor. Traffic volumes on the pre-sunrise route itself were only about 2% of those on the I-10 freeway at corresponding times. Traffic volumes on the three major surface streets crossing the pre-sunrise route, Ocean Park Blvd., Pico Blvd., (downwind of the freeway), and Olympic Blvd (upwind of the freeway) were also low, only about 8%, 6%, and 6%, respectively, of those on the freeway. Most of this early-morning cross traffic for our measurement route encountered green lights. If the emissions of the occasional vehicles on these surface streets were significant, the pollutant concentrations measured downwind of the streets should have been higher than upwind, but this was not the case; no significant gradients in concentration were observed between the two sides of these streets. Hence, the contribution of emissions from vehicles on the surface streets to our pre-sunrise measurements ranged from minor to insignificant compared to emissions from freeway traffic.

One case in which we find possible evidence of a minor contribution from non-freeway emissions involves the shallow shoulder in UFP concentrations on Ocean Park Blvd. (~950 m downwind) and shown in Figure 5.1.3.1. Traffic counts on this major surface street were ~8% of the freeway counts (Figure 5.2.4.1a), which may have resulted in a small local UFP, NO, and PB-PAH contribution to the measured concentration. A local contribution of ~6% traffic count on Pico Blvd. is not apparent in the measured UFP concentration in Figure 5.2.3.1, probably due to the closer proximity of Pico Blvd. to the I-10 freeway (~250 m downwind).

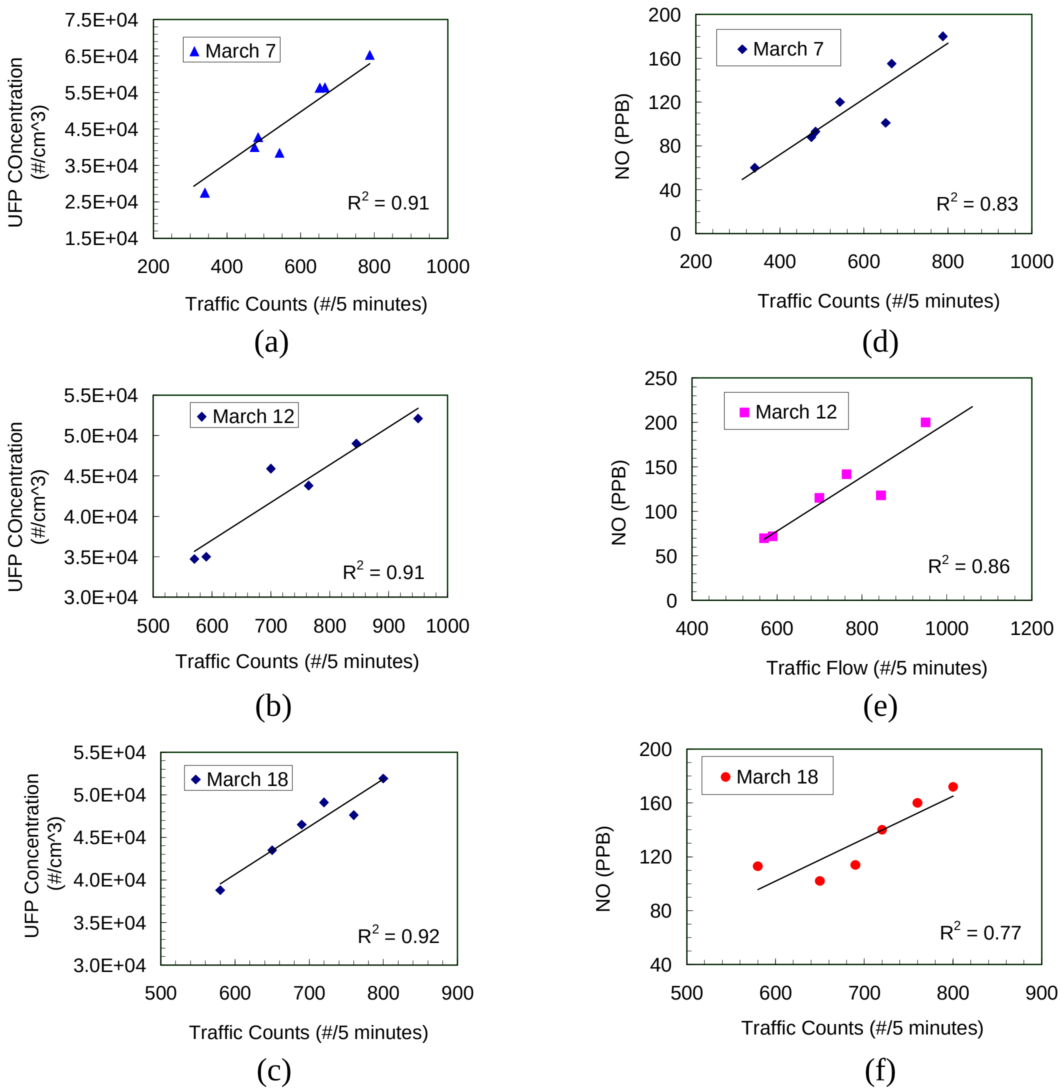


Figure 4.1.2.7. Linear regressions between UFP and NO concentrations at Ocean Park Blvd (950 m downwind of I-10 freeway), and traffic counts on the freeway during the pre-sunrise hours in the winter season.

Although the mobile platform measurements could be affected by emissions from vehicles occasionally encountered on the pre-sunrise route or cross-surface streets, these encounters typically exhibited only a short, transient spike of elevated concentrations. Furthermore, the overall pre-sunrise concentrations and gradients presented were averaged from 18-24 runs in winter and 12-16 runs in summer and for all these reasons were generally not significantly affected by emissions from occasionally encountered nearby vehicles. The Santa Monica Airport (SMA), a small local airport, located south of the pre-sunrise route, had no impact on any of our pre-sunrise measurements since it has severely restricted hours to minimize noise pollution, and was closed during all of our pre-sunrise experiments.

4.1.2.5 Size distribution of ultrafine particles along the freeway

The use of a fast mobility particle sizer (FMPS), with its 10 s scans, allowed accurate monitoring of the changing particle size distribution as a function of distance away from the freeway. Figure 5.1.5.1 shows average UFP size distributions for five downwind and two upwind intersections during the pre-sunrise hours in the winter season, with decreasing particle numbers and increasing sizes as distance downwind increases, until the upwind size distribution was roughly matched at 2 600 m. At the downwind intersections up to 1 200 m from the freeway, two to four times higher concentrations of ultrafine particles less than 40 nm were observed compared with upwind locations (Figure 5.1.5.1).

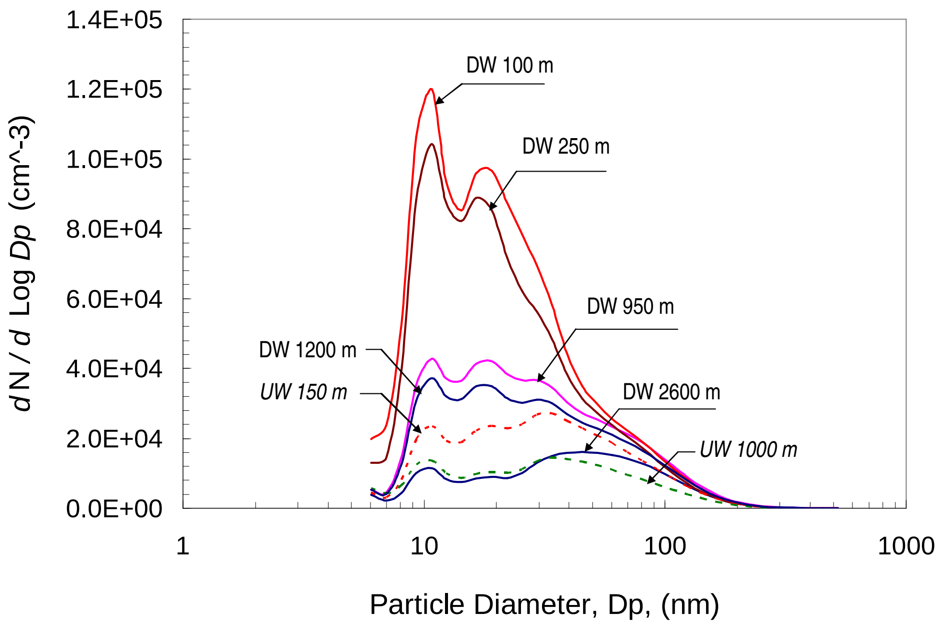


Figure 4.1.2.8. Size distributions of ultrafine particles measured by a TSI Model 3091 FMPS at upwind (UW) and downwind (DW) intersections during the pre-sunrise hours in the winter season.

For the intersections nearest the freeway (e.g. Kansas, 100 m downwind, and Pico, 250 m downwind), bi-modal peaks in the size ranges of ~9-12 nm and 16-20 nm were observed. For downwind intersections farther away and for the upwind intersections, UFP peaks observed were typically ~ 9-12 nm and ~16-20 nm , and 28-35 nm, corresponding to freshly generated UFP and aged particles, respectively. UFP size distributions at a distance of 2 600 m downwind (Palms Blvd.) and 1,000 m upwind (Harvard St), considered “background” locations, were similar with a dominant mode at 30-60 nm.

In summer, downwind UFP size distributions also had a small mode of 9-12 nm. The persistence of the 9-12 nm peak in UFP concentrations during pre-sunrise hours over a wide area can be attributed to increased condensation of organic vapors and slower rates of conversion to larger particles for the cooler, stable air conditions prior to sunrise during our winter and summer campaigns. These conditions would also promote the more elevated UFP concentrations observed in our pre-sunrise runs compared with daytime runs.

4.1.2.6 Pre-sunrise vs. daytime concentrations in present study: Exposure implications

Although traffic volumes on the freeway during the pre-sunrise hours were markedly lower than during the daytime (~ 30-80% of peak congestion traffic volumes), air pollutant concentrations measured prior to sunrise were significantly higher than in the morning or afternoon runs. Figure 5.1.6.1 shows the UFP concentrations measured at Pearl St., ~600 m south of the freeway, during the pre-sunrise and daytime hours in winter. The median UFP concentrations were 49,000 cm^{-3}, 24,000 cm^{-3}, and 19,000 cm^{-3} for the pre-sunrise, morning, and afternoon, respectively. Clearly, there was sufficient traffic flow on the I-10 freeway combined with the meteorological conditions during pre-sunrise hours to result in elevated concentrations of UFP, NO, and PB-PAH over a wide area of the downwind (up to ~2,000 m) and upwind (up to ~ 600 m) residential neighborhoods. Since the pre-sunrise hours are at a time when most people are in their homes, our observations imply the potential for elevated exposures for many more residents in these neighborhoods, adjacent to freeways; far above the numbers of people that live within the ~300-500 m range reported in earlier daytime and evening studies. Additional measurements in the pre-sunrise period downwind of other major roadways should be conducted to confirm our novel findings.

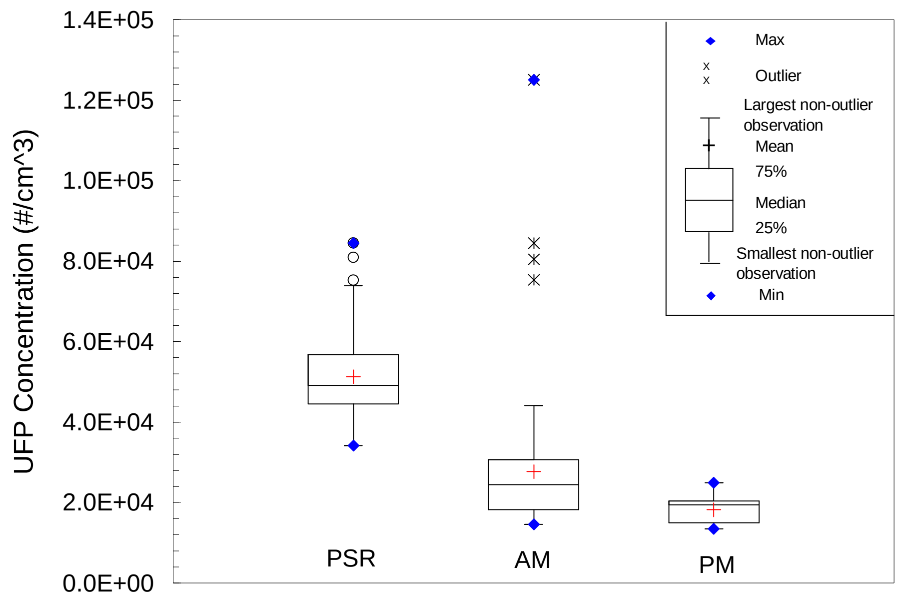


Figure 4.1.2.9. Comparison of UFP concentrations on Pearl St. (600 m south of I-10 freeway) at different times in winter: pre-sunrise (PSR), mid-morning (AM), and mid-afternoon (PM).

4.1.3 Conclusions

A wide impact area of elevated pollutant concentrations on the downwind (up to ~2,000 m) and upwind (up to ~600 m) sides of a freeway was measured during the pre-sunrise hours during typical meteorological conditions characterized by weak winds and a strong radiation inversion. To make these measurements, a mobile platform, equipped with fast-response monitoring instruments, drove along a transect crossing under the I-10 freeway and passing through a large residential neighborhood. On the upwind side of the freeway, air pollutant concentrations dropped quickly, but remained elevated up to ~600 m from the freeway. On the downwind side, air pollutant concentrations (UFP, PAH, NO) dropped much more slowly and extended far beyond the typical ~300 m distance associated with the return to background pollutant levels observed in previous studies conducted during daytime. For example, elevated ultrafine particle concentration of about 40,000 cm^{-3} extended to ~1 200 m downwind of the freeway in the winter season, which was about 40% of the peak UFP concentration adjacent to the freeway.

Although traffic volumes during the pre-sunrise hours were lower than during the day, the UFP concentrations were significantly higher in the pre-sunrise period. We attribute this pre-sunrise phenomenon to strong atmospheric stability, low wind speeds (~ 0-1 m/s), low temperatures (~9-13^{o}C), and high humidities (~61-79%), facilitating longer lifetimes and slower transport of UFP before dilution and dispersion to background levels. Nocturnal inversions are a widespread phenomenon particularly on clear nights, and our results suggest broad areas of elevated pollutants around major roadways may be common in the early morning hours. The implications of these observations for exposures to vehicle-related pollutants should be further explored.

4.2 Observation of Pollutant Concentrations Downwind of Santa Monica Airport

4.2.1 Introduction

A handful of studies have shown that air quality in the vicinity of major airports can be seriously impacted by emissions from activities of aircraft and ground support vehicles. Concentrations of ultrafine particle (UFP), particle-bound polycyclic aromatic hydrocarbon (PB-PAH), black carbon (BC), and NO_x were measured in the vicinity of Los Angeles International Airport (LAX) and markedly high UFP concentrations of about 5.0×10^{5} cm^{-3} were observed 500 m downwind of the takeoff runways (Westerdahl et al. 2008). The observed downwind UFP number concentrations were dominated by freshly generated particles with peak modes of 10-15 nm while upwind UFPs were dominated by aged particles with a mode of about 90 nm.

A study of London Heathrow Airport (Carslaw et al. 2006), reported aircraft NO_x at least 2.6 km from the airport. Approximately 27% of the annual mean NO_x was due to airport operations at the downwind airfield boundary, declining below 15% at 2-3 km. VOC, NO_x, CO, and CO_2 were measured around the Zurich Airport (Schürmann et al . 2007). The observed CO concentrations were highly dependent on aircraft movement, while NO emissions were dominated by ground support vehicles. In a study of airborne PB-PAH and vapor-phase PAH concentrations during activities of C-130H aircraft, average PB-PAH concentrations of 570 ng m^{-3} were observed 20-30 m at low and high idle, as compared to about 14 ng m^{-3} background concentrations (Childers et al. 2000).

Studies around general aviation airports are more limited. Recently, the South Coast Air Quality Management District made measurements of PM2.5, total suspended particles (TSP), lead, and ultrafine particle concentrations in the areas around Santa Monica Airport (SMA), the subject of the present study, and nearby Van Nuys Airport (Fine, 2007). They found no discernable elevation of 24 hr averaged PM2.5 mass, and highly elevated total suspended particulate lead, by up to a factor of 25 (to 96 ng m^{-3}) immediately adjacent to the takeoff area and a factor of 7 higher than background (to 28 ng m^{-3}) in the residential area. They also observed spikes in ultrafine particle number concentrations associated with aircraft departures.

Typically a buffer area isolates commercial airports from residential neighborhoods to reduce noise and pollution impacts. Small airports in heavily populated areas do not necessarily have these buffers, however, so residents may be more directly exposed to aircraft emissions. In the current study, air pollutant concentrations were measured using a mobile platform (Hu et al. 2009; Kozawa et al. 2009) during spring and summer seasons of 2008 downwind of SMA located in Santa Monica, California. SMA is a small airport operated for private aircraft and corporate jets, occupying a 1600 m by 750 m area, as shown in Figure 1. SMA is closely bounded by dense residential neighborhoods with narrow buffer areas, particularly at the ends of the runways (Figure 1). We observed markedly high concentrations of air pollutants in the residential neighborhoods downwind of SMA due to aircraft activities, particularly takeoffs, suggesting current land-use practices of reduced buffer areas around local airports may be insufficient.

4.2.2 Methods

4.2.2.1 Mobile Platform and Data Collection

A Toyota RAV4 sub-SUV electric vehicle served as the mobile platform, eliminating any potential self-pollution. Table 1 shows the sampling instruments and equipment installed on the mobile platform. Ultrafine particles were measured by a Fast Mobility Particle Sizer (FMPS) spectrometer in size range of 5.6-560 nm, which includes the UFP size range of less than 100 nm. Most instruments had a time resolution of 1-20 seconds except the Aethalometer, which had one minute time resolution. Calibration checks and flow checks were conducted on a bi-monthly and daily basis, respectively (Hu et al. 2009; Kozawa et al. 2009).

4.2.2.2 Measurement Sites

SMA experiences consistent wind patterns; the vast majority of days have a sea breeze (winds from the W to SSW) for most of the day and a land breeze at night. The runways of the airport are aligned at about 225° so that aircraft can take off into the wind. For all of our measurements, the take off direction was to the west (as is the case for at least 95% of days at SMA), with taxi and idle at the east end of the runway (E, Figure 5.2.2.1). As the airport allows operations of non-emergency aircraft only from 07:00-23:00 on weekdays and 08:00-23:00 on weekends due to noise ordinances, only daytime hours were considered. In the current study, the measurements were conducted primarily at four stationary sites (A to D indicating increasing distances from the airport) in the residential area downwind of the takeoff area (E) as shown in Figure 5.2.2.1.

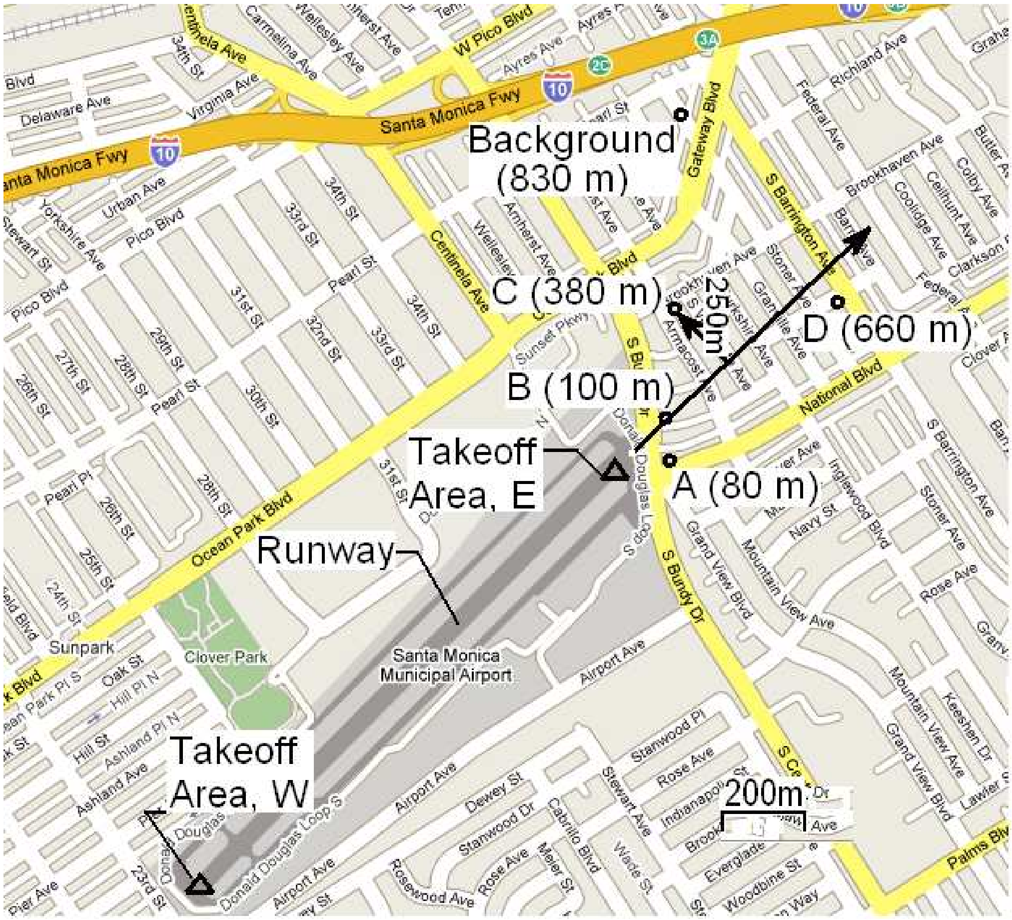


Figure 4.2.2.1. Santa Monica Airport, nearby neighborhood residential area, and measurement sites east of SMA. The distances were measured from Google Maps.

Figure 5.2.2.1 includes a line indicating the expected centerline along which emissions plumes travel during typical on-shore flow conditions, as if it is an extension of the runways in the airport. Sites B and D were selected for measurement because they are approximately on this line. Sites A and C were chosen to test the extent of horizontal impacts and are at perpendicular distances 50 and 250 m, respectively, from the extended centerline of the runways.

In spring and summer of 2008, four days of measurements were conducted: April 14 and 20, July 20 and August 8, for 4 to 6½ hours each day. The four stationary measurement sites in the residential neighborhoods downwind of the airport were sampled in random order to minimize systematic errors. In addition, the mobile platform was stopped briefly in the mornings and afternoons of three days (July 8, 10, and 12) in the summer season at Clarkson Rd, site B, and Barrington Ave, site D, to confirm the observations of elevated pollutant concentrations on the dedicated measurement days. The measurement times are listed in Table 5.2.2.2.

Table 4.2.2.1. Monitoring instruments on the mobile platform.

Instrument	Measurement Parameter	Time Resolution
TSI Portable CPC, Model 3007 [a]	UFP Count (10 nm-1um)	10 s
TSI FMPS, Model 3091	UFP Size (5.6-560 nm)	10 s
TSI DustTrak, Model 8520 [b]	PM2.5 Mass [a]	5 s
Magee Scientific Aethalometer	Black Carbon	1 min
EcoChem PAS 2000	Particle Bound PAH	5 s
Teledyne API Model 300E [c]	CO	20 s
LI-COR, Model LI-820 [c]	CO_2	10 s
Teledyne-API Model 200E [c]	NO_x, NO, NO_2	20 s
Visalia Sonic Anemometer and Temperature/RH Sensor	Local wind speed and direction, Temperature, Relative Humidity (RH)	1s
Stalker Vision Digital System	Traffic Documentation	1s

[a] The data obtained by the CPC were used only as a reference for the UFP concentrations measured by FMPS. [b] Because of concerns about the quality of the data, it is not reported here. Qualitatively, its results were consistent with the other mass-based measurements. [c] These instruments were turned off to save power for most measurement times (see text).

Table 4.2.2.2. Air traffic and meteorological conditions during the tests.

Date	Time	Arrivals (Jets) [a]	Departures (Jets) [a, b]	Wind Speed [c] ($m\ s^{-1}$)	Wind Direction [c]	Temperature (^oC)
4-14-2008	09:00-11:00	21(7)	/(3)	1.7	230	23.0
	15:30-18:00	15(8)	/(8)	2.4	235	
4-20-2008	14:00-18:00	34(13)	18(14)	2.5	261	22.0
7-08-2008	08:22-08:25	N/A [d]	N/A [d]	1.0	117	20.1
	13:20-13:46			2.2	213	21.3
7-10-2008	08:27-08:34	N/A [d]	N/A [d]	1.1	349	20.5
	13:22-13:35			1.9	204	23.8
7-12-2008	08:44-08:58	N/A [d]	N/A [d]	1.4	200	21.5
	13:24-13:34			2.1	226	24.7
7-20-2008	11:50-18:00	42(17)	20(14)	1.9	227	22.2
8-08-2008	15:30-22:00	24(9)	13(8)	3.0	237	22.2

[a] Total reported activities during the measurement time period. [b] The airport records all arrivals but only departures that exceed a specific noise threshold, thus departures exceed the values reported here. All jet departures are reported, but many small propeller plane departures are not. [c] Averaged values for the measurement periods. [d] Air traffic data are not available for these measurement periods.

4.2.2.3 Data analysis and Selection of Key Pollutants

Data were adjusted for the varying response times of the instruments on the mobile platform to synchronize the measurements (Hu et al. 2009; Kozawa et al. 2009). UFP, PB-PAH, and BC were selected in the current study for detailed spatial analysis because of their large concentration variations in the vicinity of SMA, and important implications for human exposure assessment. CO_2 concentrations were used in emission factor calculations (Section 3.3.3).

4.2.3 Results and Discussion

4.2.3.1 Meteorological Data and Background Concentrations

Meteorological conditions, including temperature, relative humidity, wind speeds and wind directions (all measured while the mobile platform was stopped), can all play a role in determining air pollutant concentrations surrounding SMA. The average wind speeds and directions are shown in Table 5.5.2.2 for the measurement times. The wind was stable and predominantly from the SW (204-261^o) in the afternoons, with speeds of 1.9-3.0 m s^{-1}. In the mornings, the wind had lower speeds of 1.0-1.7 m s^{-1}, and variable directions in a range of 117-349^o. This implies the east end of airport was always downwind in the afternoons, but not always in the mornings, and pollutant dispersion rates were higher in the afternoons.

Average background UFP concentrations were 1.7×10^4 and 5×10^3 cm^{-3} in spring and summer of 2008, respectively. Background UFP, PB-PAH, and BC concentrations, measured on Stoner Ave 830 m NNE of the takeoff area (E), on the four dedicated days, averaged $1\pm0.3\times10^4$ cm^{-3}, 5 ± 2 ng m^{-3}, and 0.3 ± 0.1 μg m^{-3}, respectively, for the spring and summer measurement periods combined (PAH data was available for only 2 of the summer days).

Measurements were made immediately preceding and/or following stops at the monitoring sites, on 12 occasions for 3-5 minutes each. The UFP concentrations at this site were relatively stable, consistent with an absence of aircraft or other strong UFP sources, even when there had been jet activity at SMA within the 7-8 minutes preceding the measurements (which happened on 5 occasions). These background values were typical of other streets around SMA away from the influence of the airport, throughout the spring and summer seasons (see also Hu et al 2009). Sampling at sites A, B and C, were about equally weighted between spring and summer, thus for these sites we use this combined average. Most of the sampling at site D, however was performed during summer, so for this site we weighted the background UFP concentrations to match the distribution of sampling, and thus use 6,000 cm^{-3} as the site D average background

4.2.3.2 Air Traffic Volumes and Aircraft Operation

Air traffic logs were provided by SMA. The numbers of arriving aircraft are listed in Table 2 for the measurement periods on dedicated days. Departures are also indicated; however, the airport only recorded activity exceeding a sound threshold of 80 db at the west end of the runway, in compliance with a local ordinance, thus small propeller plane departures were not included in the log. Based on statistics of four dedicated measurement days, the number of aircraft arrivals was about 80/day, of which about 30 were various small (6-8 passengers) to large jets (20-35 passengers), and the remainder were single and twin engine piston and turboprop planes. The diurnal hourly arrival/departure aircraft activities at SMA for the four dedicated measurement days show the great majority of aircraft operations at SMA took place during 09:00-20:00 and averaged about 6 arrivals per hour during these hours.

Jets and propeller planes taxi 800-1000 m to the take off area E. The taxi time for aircraft is about 2 minutes, much longer than the acceleration time on the runway during take-off, typically 20-25 s. Also, because the jet flight path from SMA intersects that of Los Angeles International Airport (LAX) about 16 km after take-off, jets taking off from SMA must wait for permission from LAX, resulting in an average waiting time of about 5 minutes. This implies an average taxi-waiting time of about 7 minutes for jets departing from SMA.

4.2.3.3 Impact of SMA on Downwind Residential Area

Markedly elevated concentration peaks of ultrafine particle, PB-PAH, and BC were observed downwind of SMA, extending to at least 660 m along the wind direction (site D), and 250 m perpendicular to the prevailing wind directions (site C, about 300 m downwind). At all sampling locations, when an airplane (particularly a jet) was preparing to depart, typically a loud noise was heard first (start of taxi). If the wind was from the SSW to W, the noise was followed by fuel vapor odors, and then a few minutes later by elevated concentrations of ultrafine particles, black carbon, and PB-PAH. This suggests taxiing frequently produces fuel odors, while hard accelerations are usually necessary to produce large pulses of UFP, PB-PAH, or BC.

4.2.3.3.1 Average UFP Concentrations Measured Downwind of SMA

Figure 5.2.3.1 shows UFP concentrations at the four sites during the combined spring and summer measurement periods (Table 5.2.2.2). The data are for various durations at the sites, and thus the quantity of data from each site is different. The numbers of observations for sites A, B, C, and D were 730, 5100, 470 and 1700 in 5-second averages, respectively. The average UFP concentrations at sites A, B, C, and D were 106K, 97K, 47K, and 15K cm^{-3}, respectively, about 11, 10, 5, and 2.5 times the corresponding area background levels for all measurement days combined. Figure 5.2.3.1 also shows the average BC concentrations were 2.7, 1.3, 0.8 and 0.8 $\mu g/m^3$ at the sites A, B, C, and D, respectively, elevated from the area background level of 0.3 $\mu g/m^3$. PAH data are not shown because these data are not available for all days. Both UFP and BC are elevated at all four sites, consistent with airport impacts. However, they are not elevated by exactly the same ratio at each site, for reasons we are unable to explain with current data.

Site A is located in a gas station downwind of the intersection of National Blvd. and Bundy Dr. The mobile platform was stopped at the SW, upwind, corner of the gas station, and thus measurements were not likely strongly influenced by activities in the gas station. The likely small contribution of vehicles accelerating from the intersection to the observed UFP concentrations is discussed in Section 5.3.3.3.4.

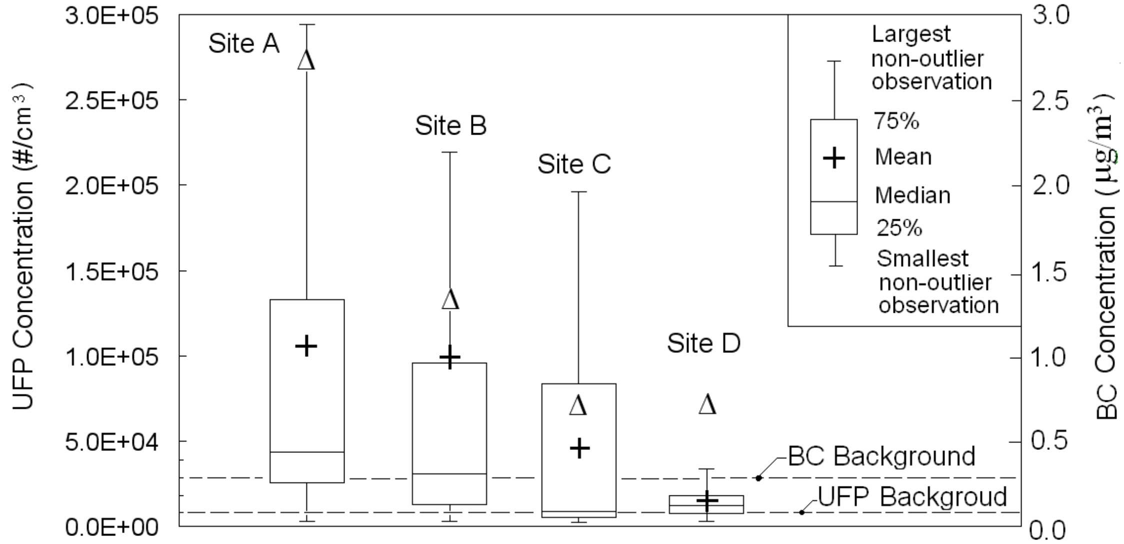


Figure 4.2.3.1. UFP concentrations at the four measurement sites during all measurement periods (Table 5.2.2.2). The symbol "Δ" indicates the mean value of BC concentrations for all measurement times. It is noted that because much less sampling was performed at Sites A and C, these data may carry higher uncertainties.

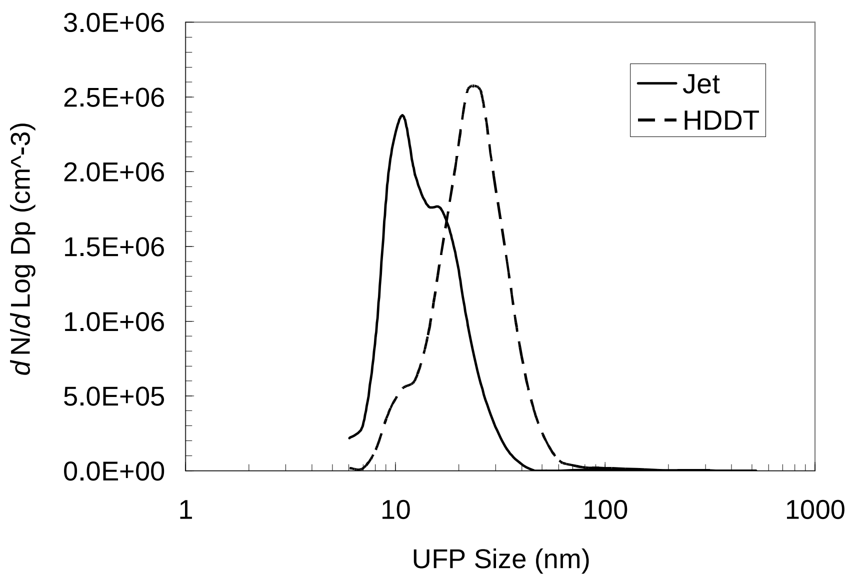


Figure 4.2.3.2. Comparison of size distribution of UFP downwind of SMA and from a heavy duty diesel truck (HDDT).

4.2.3.3.2 Size Distribution and Mass of UFP Downwind of SMA

Sixty jet emission size distributions at SMA were analyzed. Aircraft emissions produced UFP with a median size mode of about 11 nm with little variability, consistent with the observations at LAX (Westerdahl et al 2008). Figure 5.2.3.2 shows a representative size distribution of ultrafine particles from a jet takeoff. This peak had a UFP concentration of 1.0×1□ cm□. Figure 5.2.3.2 also shows a representative size distribution of UFP from an isolated heavy duty diesel truck (HDDT) measured by our MP on a surface street in the downtown area of Los Angeles. The peak UFP concentration was also about 1.0×10^{6} cm^{-3}, but the mode, about 22 nm, is significantly larger than the modes of the UFP distributions observed from aircraft. The peak UFP concentrations from the aircraft and HDDT were about 100 and 25 times the background levels (which were not subtracted), respectively. Size distributions were collected after the emissions plumes had been diluted sufficiently that they would not be undergoing significant self coagulation, which has been calculated to be any time after the first 1-3 seconds following exhaust released from the tail pipe (Zhang and Wexler 2004).

Aircraft activity clearly results in markedly elevated UFP number concentrations, but because UFPs are so small, they make only modest contributions to mass concentrations. For example, the average number concentration at Clarkson site B (100 m downwind) was about 9.7×10^{4} cm^{-3} during the measurement periods, ten times the area background level. The calculated mass contribution of UFP caused by aircraft averaged 0.6 $\mu g\ m^{-3}$, assuming a particle density of 1.2 $g\ cm^{-3}$ (Westerdahl et al 2008), only about 3% of the annual basin background level of ~18 $\mu g\ m^{-3}$ of PM2.5. If 24-hr measurements were conducted to obtain average particle mass concentrations, the contribution of aircraft-related UFP during the aircraft operation period, typically 07:00-23:00, would be even smaller, consistent with the SCAQMD measurements (Fine 2007). It should be noted, however, that potential health effects of UFP generally focus on the size and number of such particles and not their mass (e.g. Zhang and Wexler 2004).

4.2.3.3.3 Relationship Between Downwind Pollutant Concentrations and Aircraft Events

Figure 4 shows typical time series of air pollutants measured at site B downwind of idle/take off area E (Fig. 5.2.2.1) at SMA on the afternoon of July 20, 2008. On others days of measurements, similar elevated air pollutant concentrations, at least 10 times the seasonal background level, were repeatedly observed at the four sites. Note that the time of aircraft departures from the SMA log and peak UFP concentrations are very close, but do not always correspond perfectly. This may be due to occasionally high aircraft emissions during taxi as well as deviations resulting from the resolution of the airport log data (1 minute), and variable travel time of the plume from the departure monitor, which is located near the west end of the runway (take off area W, Fig. 5.2.2.1).

Extremely high pollutant concentrations were observed at Site B, Clarkson Rd, 100 m downwind of SMA, specifically associated with jet operations at the airport. The Figure 5.2.3.3 time-series plot for site B shows UFP, PB-PAH, and BC as well as aircraft arrivals and some departures (upper abscissa) during the times of measurement. Here, multiple incidences of elevated air pollutant concentrations corresponded to jet departures, propeller aircraft departures, and possibly, aircraft arrivals. For example, at 12:20 (from the airport log) a Gulf Stream 4 jet (GLF4, 33200 kg) departed, an event followed by measured concentrations of 60-second average PB-PAH and BC of 440 ng m^{-3} and 30 μg m^{-3}, respectively, resulting in elevated ratios of about 90 and 100 times the summer background levels, respectively. Both pollutants returned to background levels within about 3 minutes after the jet's departure. Additional spikes were observed associated with jet operations at 12:35, 12:36, 12:58, and 13:00 with 60-second average UFP concentrations up to about 2.2×10^6 cm^{-3}, about 440 times the summer background level. UFP concentrations remained elevated, hovering around 10^5 cm^{-3} for the remainder of the sampling period. The trace indicates that while arrivals of small aircraft, as well as taxi, idle and takeoffs (although these do not appear in the log) release significant quantities of UFP, they do not appear to produce significant elevations of PB-PAH or BC.

As noted above, the average taxi and waiting of a jet before departure is about 7 minutes, but significantly longer taxi/waiting periods occurred from time to time. For example, during measurements at Site B, a loud noise was recorded from 12:07 until 12:20, during which time the particularly large jet (GLF4) was taxiing and waiting for take-off. The peak at 12:12 and the following elevated UFP concentrations (Figure 5.2.3.3) were associated with this idling jet prior to its departure at 12:20. Figure 5.2.3.3 also shows a trace from later in the afternoon, a period with much lower aircraft activity and much lower UFP concentrations, which sometimes dropped to the summer background level of about 5,000 cm^{-3} for several minutes at a time.

Significantly elevated pollutant concentrations were also observed at other three sites. For example, during one hour measurement on July 20, 2008 (13:04-14:03) at site D, just west of Barrington Ave, 660 m downwind of SMA, the UFP concentration was elevated above the summer background (5,000 cm^{-3}) for most of the period, due to multiple aircraft operations (including taxi). The mean of the UFP concentration during this measurement period was 1.5×10^4 cm^{-3}, about 3 times the summer background level. Spikes of PB-PAH and BC associated with aircraft activity were not observed at this site.

4.2.3.3.4 Potential Contribution from the Surface Street Immediately Downwind of the Airport

As noted earlier, a major surface street, Bundy Dr, ("Bundy", Figure 5.2.2.1), is located immediately east of SMA, between the usual aircraft take off area (E) and the measurement sites (A-D). To investigate the possible contribution of traffic on Bundy to elevated pollutant concentrations observed at site B, we reviewed traffic data on this street and also compared measurements made on nearby stretches of Bundy not influenced by the airport during the same sampling days as the aircraft measurements. The traffic flows on Bundy were recorded on digital video when the mobile platform was stopped at site B, and when traveling on nearby stretches of Bundy immediately preceding and following stops at the sampling sites around the SMA. The traffic counts on Bundy Dr. (and on National Blvd.) during our measurement times averaged 50-60 counts per minute, small compared to nearby freeways which have 200-300 vehicles min^{-1} during daytime. Traffic on this road is dominated by newer gasoline vehicles; further, only five heavy duty diesel trucks were encountered during 650 minutes of sampling on Bundy within 1.8 km of SMA.

Average on-road UFP concentrations on sections of Bundy removed from the airport impacts, but within 1,800 m of SMA were much lower than observed at site B (25 m from Bundy), averaging 35,000 cm^{-3} during the sampling days listed in Table 5.2.2.2 (220 minutes of data). At site B in the absence of aircraft activity (Fig. 5.2.3.3), the UFP concentrations were low, in the range 5,000-15,000 cm^{-3}, indicating the contribution of traffic on Bundy to the average UFP measurement at site B, was less than 15,000 cm^{-3}. About one third of the Site B UFP concentrations fell below 15,000 cm^{-3}, distributed reasonably evenly among the measurement periods. High-emitting vehicles (HEV) can cause large spikes of UFP concentrations, over 10^6 cm^{-3}, but these vehicles were rare (above). Vehicle-related UFP spikes are also brief, lasting less than 30 s for solo vehicles, and even shorter times in traffic. Hence, the contributions of high emission vehicles on Bundy to the average UFP concentrations measured at Site B were small, and HEV are unable to explain the frequent elevated UFP lasting 2 minutes or longer (e.g. Fig. 5.2.3.3a) observed at the site B. This reinforces that the elevated pollutant concentrations we measured at site B were due to the emissions from aircraft at SMA. Similarly, we believe the elevated UFP concentration measured at site A in the gas station was dominated by aircraft, not by vehicle emissions from the intersection of Bundy Dr. and National Blvd.

4.2.3.3.5 Comparison of Impact Areas from Santa Monica Airport and Freeways During Daytime

Measurements made in Southern California (Hu et al 2009; Zhu et al 2002b) indicated UFP and other vehicle-related pollutant concentrations return to background by about 300 m downwind of major roadways during daytime, although the impact distance is much greater prior to sunrise (Hu et al 2009). In the current study, average UFP concentrations 660 m downwind of SMA during the daytime were about 2.5 times (all data) and 3 times (summer only) the background, indicating a much greater impact distance for the airport than for roadways. Similar to our observation, elevated UFP concentrations were observed 900 m downwind of a runway at Los Angeles International airport (Westerdahl et al 2008). The phenomenon was attributed to landing aircraft passing within a few hundred meters overhead, combined with incomplete dilution of the high numbers of UFP emitted from aircraft during takeoff.

We believe the relatively long impact distance downwind of SMA, further than 660 m, is a result of the higher initial concentrations of UFP in aircraft emissions, combined with their larger volumes relative to vehicles. As far as we are aware, studies of particle emissions directly from aircraft are limited to large jets. We estimated UFP emissions per kg of fuel consumed from the jet aircraft operated at SMA for cases where we observed departures that produced clear isolated spikes in both CO_2 and UFP. Two suitable isolated peaks observed at the stop at site B on August 8 indicate the aircraft emissions contained roughly 5×10^{16} particles/kg of fuel consumed. The CO_2 difference was 12 ± 1.5 ppm, and the UFP difference was $(3.7\pm0.5)\times10^5$ particles cm^{-3}. Large aircraft emissions have been reported to contain a range of $0.3\text{-}5\times10^{16}$ particles/kg of fuel consumed (Lobo et al 2007; Herndon et al 2005). Our estimate for SMA is at the high end of this range. Also for commercial gas turbines, high particle numbers have been reported at lower thrust levels associated with lower fuel consumption rates (Lobo et al

2007), suggesting that even with much lower fuel consumption rates, aircraft taxi and idle may be a significant source of UFP.

Our UFP emissions estimates for aircraft at SMA are 16 to 100 times higher than UFP emitted per kg of fuel consumed by light duty vehicles (5×10^{14}-3×10^{15} particles/kg) (Kirchsteter et al 1999; Geller et al 2005) and 5 to 8 times higher than heavy duty vehicles (6×10^{15}-1×10^{16} particles/kg) (Kirchsteter et al 1999; Westerdahl 2009). Although the on-road vehicle values were measured under a range of typical on road conditions, and thus are not directly comparable to our aircraft measurements which are dominated by idle/low load and maximum load conditions, they are each real-world estimates relevant to exposure assessment.

Aircraft fuel consumption rates during takeoff are roughly 50-300 g s^{-1} for small piston or turboprop planes and can be up to about 500-5,000 g s^{-1} for the types of jets that operate at SMA (Humphrey 2009), much higher than rates for motor vehicles of 1-10 g s^{-1}. The fuel consumption rates for jets during takeoff tend to be high (up to several times those during cruise) because the jet engines are designed for high speeds and at high altitudes. This means aircraft emissions, especially during takeoff, have much higher volumetric flow rate than that of motor vehicles. This large volume of high concentration aircraft emissions is expected to take longer to be dissipated and diluted to the background level than vehicle emissions on roadways, consistent with our observations.

Zhang and Wexler proposed a model of aerosol dilution near roadways (Zhang and Wexler 2004). They suggested a dilution ratio of about 1000:1 is complete in the first 1-3s during the ‘tailpipe-to-road’ stage, and an additional 10:1 dilution is completed in the following 3-10 minutes, the ‘road-to-ambient’ stage. Dilution of aircraft emissions at the SMA are also complicated by the topography immediately east of SMA. The takeoff area is about 9 m higher than the measurement site B. Aircraft emissions need to first pass over a fence, about 3.5 m high, designed to mitigate noise and emissions impacts on neighborhoods, and then to pass over Bundy Dr to move into the downwind residential neighborhoods.

The travel times for pollutants to site B, and from the site B to D were 17-50 s and 1.5-6 minutes (corresponding to wind speeds of 2-6 m s^{-1}), in the range of the wind-shear-dominated second stage “road- to-ambient” dilution period (Zhang and Wexler 2004). This implies a dilution ratio at site B *vs.* site D of 10:1 or less. The average summer UFP concentrations at sites B and D were 8.9×10^4 and 1.5×10^4 cm^{-3}, respectively, indicating a dilution factor of about 8, for summer background concentrations of about 5,000 cm^{-3}. This dilution factor is consistent with our estimates above, implying that the larger downwind impact area of the airport compared to that of roadways results from the large volumetric pulse of high concentration emissions produced by aircraft.

4.2.3.3.6 Correlation of Site B UFP Concentration and Estimated Aircraft Fuel Consumption Rates

To compare measured UFP concentrations with airport activities, we estimated aircraft fuel consumption rates at take off. Aircraft weight (*m*), passenger number, activity type (departure/arrival), take off length (*L*), and indicated aircraft speed (*U*, the aircraft velocity leaving the ground), determine the fuel consumption rate of ($\dot{m}_{fuel}$) during take off. Values for *m*, *L*, and *U* were obtained from aircraft specifications. Passengers, crew, and luggage usually add 6-15% of aircraft weight. If a constant acceleration rate of aircraft on the runway is assumed,

$$L = at^2 / 2 \tag{1}$$

$$U = at \tag{2}$$

$$m_{fuel} \propto mU^2 C_0 C_1 / 2 \tag{3}$$

Here, *a* is the aircraft acceleration rate on the runway; *t* is the time of aircraft spent on the runway during acceleration; m_{fuel} is the total fuel mass consumed by aircraft during acceleration; C_0 is the overall conversion efficiency of energy from fuel to aircraft kinetic, and C_1 is a constant accounting for the weight of the passengers, crew, and luggage. Here, the same C_0 and C_1 are assumed for all aircraft. Combining equations (1)-(3), we obtain a fuel consumption rate for aircraft during acceleration on the runway as:

$$\dot{m}_{fuel} \propto mU^3 / L \tag{4}$$

For similar atmospheric conditions and assuming the same dilution ratio of emissions from all aircraft, the peak UFP concentrations measured at site B should be roughly proportional to the peak air pollutant concentrations emitted from an aircraft, which are proportional to the fuel consumption rate during take off. The jets at SMA are heavier (7,000-33,000 kg), faster (indicated aircraft speed, or IAS, of 70-90 m s^{-1}), and have longer take off lengths (1000-1800 m) than propeller aircraft. The calculated $\dot{m}_{fuel}$ was 5-10 times larger for jets than propeller planes.

Reasonable correlations were observed between the measured peak UFP concentrations at site B and the parameter mU^3 / L for aircraft departures associated with spikes in UFP concentrations measured at site B. The measured UFP concentrations and the associated aircraft code, type, weight, takeoff distance, and takeoff speed, are listed in Table 5.2.3.1. The squared Pearson correlation coefficient (r^2) of 0.62 indicates UFP emissions and hence concentrations are reasonably related to aircraft fuel consumption rate. In general, larger aircraft are associated with higher emissions and downwind concentrations of UFP.

Table 4.2.3.1. Information about aircraft active at SMA

	Code	Type	Passengers	Weight(kg)	Takeoff distance (m)	Takeoff IAS ($m\ s^{-1}$) [a]	Associated Peak UFP Concentration (# cm^{-3})
1	BE36	Piston	6	1650	350	50	1.0×10^5
2	BE58	Piston	4-5	2500	700	65	2.5×10^5
3	BE40	Small Jet	6-8	7300	1200	80	3.6×10^5
4	C152	Piston	1	760	220	44	8.5×10^4
5	C441	Turboprop	9	4470	550	65	1.2×10^5
6	C550	Small Jet	6	6850	1000	75	3.4×10^4
7	C560	Small Jet	8	7210	963	65	7.3×10^5
8	C750	Large Jet	12	16193	1740	80	1.8×10^6
9	F2TH	Large Jet	9-19	16240	1600	75	1.3×10^6
10	H25B	Mid Jet	8-14	12430	1700	75	6.6×10^5
11	LJ35	Small Jet	6-8	8300	1300	87	1.6×10^5
12	E135	Large Jet	35	19990	1400	82	/
13	GLF4 [b]	Large Jet	14-19	33200	1600	90	4.6×10^6

[a] Indicated aircraft speed; the speed as the aircraft leaves the ground.

[b] Peak UFP concentration of GLF4 shown here was not included in the correlation because its fuel consumption rate estimated from Eqn (4) (see text) was an outlier from the cluster of values for other aircraft.

4.3 Exploratory Research: Evidence of a Disproportionate Contribution of High-Emitting Vehicles to on-road UFP Concentrations in Boyle Heights

In the course of measurements on the mobile platform route in downtown Los Angeles (DOLA) that passed through Boyle Heights (BH) we observed nearly uniform and elevated UFP concentrations across the community. One possible explanation (although not the only explanation) for the relative absence of strong concentration gradients near the major roadways surrounding BH is a high incidence of high-emitting vehicles (HEVs), including high-emitting gasoline vehicles (HEGV), within the BH community. In this section of the report we present a preliminary evaluation of the potential contribution of HEV to the UFP counts we observed in Boyle Heights.

5.3.1 Fraction of UFPs in BH Attributable to HEV

Over the past 25 years many studies have shown that a relatively small fraction of the light-duty motor vehicle fleet (typically 5-10%) have been responsible for a large fraction (as much as 50% or more) of the total fleet emissions of pollutants such as CO, VOC, and NOx (Lawson et al 1990; Stephens and Cadle 1991). To date, however, we are not aware of a similar demonstration for emissions of UFPs. We emphasize our study did not directly measure emissions of UFP at the tailpipe from specific vehicles. However, when we observed an UFP concentration above a certain threshold (e.g. 100 000 cm^{-3}) it could almost always be attributed to the emissions of a nearby vehicle. It is reasonable to assume that the concentrations we measured are roughly proportional to the emission rate of UFP from such high-emitting vehicles given our close proximity to the exhaust (typically 1-2 m). Indeed, in some cases we were able to identify from videotapes a specific isolated HEV immediately in front of our MP as responsible for an elevated UFP concentration above the chosen threshold. In some cases these elevated concentrations exceeded one million particles per cubic cm.

5.3.1.1 Choice of UFP Concentration Threshold

For the analyses conducted here, we chose twice the average UFP concentrations in the residential area and surface street microenvironments of BH, respectively, as a threshold UFP concentration. Above this threshold there is a high likelihood a high-emitting vehicle was encountered. The average UFP concentrations in the residential areas and on major surface streets in BH were about 30 000 cm^{-3} and 50 000 cm^{-3}, respectively, quite high compared with WLA, presumably due to the many freeways surrounding and intersecting the BH area.. Hence, we chose threshold UFP concentrations of 60 000 cm^{-3} and 100 000 cm^{-3} for measurements in the residential areas and on the surface street, respectively.

5.3.1.2 Calculation of Percent Time UFP Concentration was Above Threshold

We first averaged all UFP data to 5 sec averages and then sorted all UFP sampling data points in a decreasing sequence. Then, as discussed in the preceding section, we chose a threshold UFP concentration, C_i, as a benchmark concentration to subgroup the UFP data points. The cumulative data point, *Ni*, is the number of all the UFP concentrations above the C_i, threshold. We then evaluated the cumulative fraction of data points AN_i as:

$$AN_i = \frac{N_i}{N} \qquad (1)$$

Here, *N* is total number of UFP 5-second sampling data points for either residential neighborhoods or major streets.

Note the fraction of total data points is the same as the fraction of total measurement time.

5.3.1.3 Calculation of Percent of Total UFPs Measured When Concentration Exceeded Threshold

UFP concentrations were obtained by the FMPS instrument which was set to a constant sampling flow rate during all measurements. Hence, The UFP count, *P*, can be expressed as:

$$P = Flowrate * Time * C_{UFP} = Const * C_{UFP} \qquad (2)$$

The UFP concentrations we measured could thus be directly used to evaluate the fraction of UFP counts. The cumulative UFP count, P_i, is proportional to the sum of all the UFP concentrations above C_i.

$$P_i = const * \sum C_{UFP} \quad \text{for } C_{UFP} > C_i \qquad (3)$$

$$P_{total} = const * \sum C_{UFP} \quad \text{for all UFP concentrations} \qquad (4)$$

$$AP_i = \frac{P_i}{P_{total}} \qquad (5)$$

Here, P_{total} is the sum of all the ultrafine particles measured in residential area or major surface streets. *Pi* is the sum of all the ultrafine particles for UFP concentrations above the selected threshold. AP_i is cumulative fraction of UFPs contributed from UFP concentrations above C_i threshold.

5.3.1.4 Attribution to HEV

The small fraction of time associated with HEV encounters contributed a significant fraction of ultrafine particles in the residential areas and on the major surface streets in BH, as shown in Table 5.3.1.4.

Table 5.3.1.4.Percent of time HEV encountered and percent of total ultrafine particles from HEV in BH

	Morning	Afternoon	Overall
In residential neighborhoods:			
Percent of time HEV encountered	*5%*	*4%*	*5%*
Percent of total UFPs from HEV	*26%*	*12%*	*18%*
On major surface streets:			
Percent of time HEV encountered	*13%*	*5%*	*8%*
Percent of total UFPs from HEV	*47%*	*19%*	*28%*

For the residential areas, UFP concentrations associated with HEV were above 60,000 cm^{-3} (twice the area average), about 5% of the time in the mornings but contributed up to 26% of the ultrafine particles we measured in the morning were on our route in BH, as shown in Table 5.3.1.4. In the afternoons, UFP concentrations were above 60,000 cm^{-3} about 4% of the time, but contributed about 12% of the total ultrafine particles we measured on our route, Table 5.3.1.4. The lower contributions of HEV to the UFP counts in the afternoons may due to the significant contribution of secondary aerosol formation in the afternoon as discussed earlier.

On the major surface streets, UFP concentrations were above 100,000 cm^{-3} due to HEV encounters about 8% of the time, yielding 28% of the ultrafine particles measured on our route. UFP concentrations were above 100,000 cm^{-3} in the mornings about 13% of the time but accounted for nearly 50% of the ultrafine particles on the route. Clearly a relatively small fraction of the vehicles on the major surface streets and in the residential areas in BH make a significant contribution to ultrafine particles in this community.

5.3.1.5 Conclusion

The relatively small fraction of HEV in the total vehicle fleet contributed a significant fraction of the total ultrafine particles we observed on our route. For example, although encounters with HEVs accounted for only about 5% and 13% of the time spent on monitoring in the residential areas and on major surface streets, respectively, in the morning, we calculated HEVs contributed approximately 25% and 50%, respectively, of total ultrafine particles measured on the route we studied. Secondary photo-oxidation reactions may also contribute partially to the elevated UFP concentrations we observed across the entire residential area, especially in the early afternoons. The pollutant concentrations we observed in BH may have important implications for human exposure for the residents of this area and raise environmental justice issues associated with the high traffic flows around and through a community that has a relatively lower vehicle ownership rate compared with nearby more affluent areas.

5.0 TIME-LOCATION PATTERNS OF HARBOR COMMUNTY RESIDENTS

5.1 Introduction

Understanding location and microenvironment activity patterns is essential for assessing and modeling environmental exposures, and integration of traditional data collection methods with advances in Global Positioning Systems (GPS) technologies provides opportunities for documenting the understudied time-location patterns of disadvantaged communities. Time-activity data have traditionally been based on random telephone recall surveys such as the National Human Activity Pattern Survey (NHAPS) in the continental USA which require participants to recall their activities of the previous day (Wiley et al., 1991; Klepeis et al., 2001; Leech et al., 2002), or activity logs or time-location diaries on which participants record their microenvironments and location characteristics during observation days (Weisel et al., 2005; Nethery et al., 2008).

Several regional travel surveys have tracked travel activities by equipping passenger vehicles with GPS (Murakami and Wagner, 1999; Zmud and Wolf, 2003) and recent cohort studies demonstrate that portable GPS loggers and GPS-enabled cell phones are valuable new tools for monitoring subject locations in exposure studies (Phillips et al., 2001; Elgethun et al., 2003; Elgethun et al., 2007; Rainham et al., 2008; Wiehe et al., 2008). Portable GPS devices can track subject locations in everyday activities over the course of the day, reduce respondent reporting burden, and enable the data collection over longer periods. GPS data can also be used to validate self-reported time-activities, identify activities that participants did not self-report, and provide the basis for follow-up interviews to verify activity patterns and microenvironment characteristics (Bachu et al., 2001; Stopher et al., 2002; Wolf et al., 2004; Doherty et al., 2006; Flamm, 2007). Unfortunately, available time-activity data provide few insights into the patterns of lower-SES populations due to methodological and sampling limitations.

The Harbor Communities Time Location Study (HCTLS), conducted as part of the large Harbor Community Monitoring Study (HCMS), integrated the use of activity logs, GPS tracking, and follow-up surveys in order to document the multiple-day diurnal time-location patterns of forty-seven adult residents of the largely low-income and Hispanic communities immediately adjacent to the Ports of Los Angeles and Long Beach. These communities are heavily impacted by multiple sources of air pollution from nearby port, goods movement, and refinery operations and although stationary and mobile monitoring are providing new insights into the near-port distribution of air pollution (Krudysz et al., 2008; Kozawa et al., 2009; Krudysz et al., 2009), little is known about the time-location patterns of residents in these communities and their associated in-vehicle, indoor and outdoor air pollution exposure.

This section documents the activity and microenvironment patterns of HCTLS participants and demonstrates the usefulness of integrating multiple tracking and verification methods to examine the time-location patterns of disadvantaged communities. We assess the extent to which this largely female, low-income, Hispanic, and immigrant group differs from comparable subgroups of the national NHAPS survey. Although modeling participant air pollution exposure is beyond the scope of this study, we examine the extent to which HCTLS participants spent time in proximity to heavily-travelled roadways and truck routes since vehicle-related air pollutants and related health impacts, including the prevalence of respiratory ailments and mortality, are highly localized during the day within approximately 200-300 meters downwind of major roadways (Zhu et al., 2002a; Zhu et al., 2002b; Sioutas et al., 2005; Lipfert and Wyzga, 2008; Hu et al., 2009). We also conducted very limited sampling of PM mass and number during the baseline and exit interview stages of the HCTLS study, yielding data on the indoor particulate concentrations in the residences of the HCTLS study participants, the only data on indoor pollutant levels collected during the Harbor Community Monitoring Study.

5.2 Methods

5.2.1 Study Design

The HCTLS population was a nonrandom sample of 51 adult residents (21-65 years old) of the Wilmington area of the City of Los Angeles, California and the western portion of the City of Long Beach, California. We recruited participants through contacts with community health organizations, presentations at community meetings and adult education classes, informational tables at community events, fliers and advertisements in public spaces, and networking through word of mouth and through participants of previous studies.

Recruitment materials, training, and participation coordination were available in both English and Spanish given residents of the study area are predominately Hispanic and bilingual and monolingual Spanish speakers. Participants expressed concern about air pollution problems in their community and were highly motivated to help gather information that could support policy and planning solutions. Time-location data tracking was conducted between February and June 2008. Participants received grocery gift cards totaling $50 for their participation which included an in-home baseline survey and training, completion of time-activity logs for 3 days, 10-14 days of GPS location tracking, and an in-home follow-up interview.

During the initial in-home meeting we provided an overview of the study, gained informed consent, trained participants on completing the activity logs and operating the GPS devices, and conducted the baseline survey to gain demographic and SES information, household and building characteristics related to the potential intrusion of outdoor air pollution, household transportation resources, and general health status information. After the completion of participant activity tracking, we retrieved logs and GPS devices, generated map and tabular "prompts" regarding discrepancies, unclear patterns, and suspected unreported activities, and returned to participant homes to conduct follow-up interviews. We conducted very limited sampling of PM mass and number during the baseline and exit interviews.

This section examines the time-location patterns for the 131 days on which 47 of the HCTLS participants adequately recorded their 24-hour location patterns using both self-reported time-activity logs and passive location tracking with a portable GPS device. Four of the original 51 participants were eliminated from the analysis because their data for "simultaneous" log-GPS tracking days were incomplete due to temporary GPS device errors or malfunctions, participant failure to keep the GPS with them at all times, or participant failure to adequately complete activity logs. Of the 47 participants included in the analysis, data were available for 3 “simultaneous” days for 37 participants and 2 “simultaneous” days for 10 participants due to similar problems.

During the “simultaneous” log-GPS activity tracking days included in the analysis, participants completed a line on the activity log each time they changed location by recording the time, checking whether they were Indoors (Home, Work, School, Other), Outdoors (Walking, Biking, Other), or In-Vehicle (Auto, Van, or Truck, Transit, or Other), and noting location details (Figure 6.2.1.1). Log completeness and detail varied

TIME WHEN YOU WAKE UP	LOCATION (home, family/friends home, etc)	NOTES

Record every time you change location. Check only one box per row

TIME IN NEW LOCATION	INDOORS	OUTDOORS	IN-VEHICLE	NOTES
AM PM	❑ Home ❑ Work ❑ School ❑ Other	❑ Walking ❑ Biking ❑ Other	❑ Auto, Van, or Truck ❑ Transit ❑ Other	
AM PM	❑ Home ❑ Work ❑ School ❑ Other	❑ Walking ❑ Biking ❑ Other	❑ Auto, Van, or Truck ❑ Transit ❑ Other	
AM PM	❑ Home ❑ Work ❑ School ❑ Other	❑ Walking ❑ Biking ❑ Other	❑ Auto, Van, or Truck ❑ Transit ❑ Other	
AM PM	❑ Home ❑ Work ❑ School ❑ Other	❑ Walking ❑ Biking ❑ Other	❑ Auto, Van, or Truck ❑ Transit ❑ Other	
AM PM	❑ Home ❑ Work ❑ School ❑ Other	❑ Walking ❑ Biking ❑ Other	❑ Auto, Van, or Truck ❑ Transit ❑ Other	
AM PM	❑ Home ❑ Work ❑ School ❑ Other	❑ Walking ❑ Biking ❑ Other	❑ Auto, Van, or Truck ❑ Transit ❑ Other	

(a) English Time-Activity Log

TIEMPO CUANDO DESPERTO	LOCALIZACIÓN (SU casa, casa de famila/amigos, etc)	NOTA

Apunta cada tiempo que cambia de localización. Marque solo una caja por fila

TIEMPO EN NUEVO LOCALIDAD	DENTRO	AL AIRE LIBRE	EN-VEHÍCULO	NOTA
	❑ Casa ❑ Trabajo ❑ Escuela ❑ Otro	❑ Caminando ❑ Andando en Bicicleta ❑ Otro	❑ Auto, Van, o Camioneta ❑ Tránsito Publico❑ Otro	
	❑ Casa ❑ Trabajo ❑ Escuela ❑ Otro	❑ Caminando ❑ Andando en Bicicleta ❑ Otro	❑ Auto, Van, o Camioneta ❑ Tránsito Publico❑ Otro	
	❑ Casa ❑ Trabajo ❑ Escuela ❑ Otro	❑ Caminando ❑ Andando en Bicicleta ❑ Otro	❑ Auto, Van, o Camioneta ❑ Tránsito Publico❑ Otro	
	❑ Casa ❑ Trabajo ❑ Escuela ❑ Otro	❑ Caminando ❑ Andando en Bicicleta ❑ Otro	❑ Auto, Van, o Camioneta ❑ Tránsito Publico❑ Otro	

(b) Spanish Time-Activity Log

Figure 5.2.1.1. Sample HCTLS Time-Activity Logs

in part because of limited literacy skills of some participants and the frequency with which participants recorded activities. Participants also kept a portable GlobalSat DG-100 GPS device with them during waking hours on the observation days. These devices were relatively light-weight and were typically carried in a pocket or bag or clipped onto a belt, required nightly charging, and recorded the geographic coordinates of participant locations about every 15 seconds.

5.2.2 Enhanced Location Classification Using GPS Data and Follow-up Interviews

We examined GPS patterns using Geographic Information Systems (GIS) to overlay participant GPS coordinate locations over highly resolved and geographically rectified Digital Ortho Quarter Quads (DOQQ) aerial photography for July 2006 from the United States Geological Survey (USGS) in order to identify the time participants spent in major microenvironments (indoors, outdoors, and in-vehicle), traveling by mode (walking, biking, on transit, and in-vehicle), and major location type (home/residential, public building, service or school locations, workplace, retail, restaurant/bar, outdoors, and traveling/waiting outdoors or in an enclosed vehicle). We determined GPS point locations relative to building outlines and built environment features using DOQQ imagery, and we used GIS land use data, our knowledge of the study area, and the "satellite" and "street view" function of GoogleMaps (http://maps.google.com/) in order to confirm built environment configurations and to clarify location type/function. Participant notes and location information from logs helped further clarify details such as building location type (i.e., residence or retail location) or travel mode (i.e., traveling in a vehicle or on transit).

The positional accuracy of GPS point locations (compared to reported or probable participant locations) varied depending on whether a participant was outdoors or in close proximity to or inside a building. Consistent with previous studies (Phillips et al., 2001; Elgethun et al., 2003; Rainham et al., 2008), we found that when participants were walking on a sidewalk with no obstructions blocking the sky (i.e., trees, awnings, large signs, etc) the location of their mapped GPS points were generally within 3-5 meters of the sidewalk on DOQQ images but could appear 20 meters or more from the sidewalk when they passed a 3-5 story steel frame structure. When participants were inside a wood frame single family home or apartment building their GPS points generally at times appeared within 5-20 meters outside of their building depending on their proximity to a window or doorway. Although we consistently identified when participants left or arrived at a given location, we could not distinguish time on patios or outdoor spaces near buildings from indoor time due to this positional GPS error and therefore classified points after arrival and before departure of a building as indoors. GPS signal reception was completely lost when participants were in large steel frame structures such as high rise apartments or medical facilities, but we approximated their indoor time based on the GPS points of their arrival and departure.

We overcame the challenges of classifying GPS data and generated a highly-resolved 15-second interval spatial database with microenvironment, travel, and location attributes. We compared this database to participant logs in order to generate prompts for follow-up interviews to identify potential unreported locations and to clarify travel mode, trip purpose, and the characteristics of microenvironments. Because of the time required for post-processing GPS data and logistics, follow-up interviews were conducted 2-5 weeks after the monitored days. We finalized the HCTLS database for the 131 analysis days based on feedback from these interviews.

5.2.3 Unreported Locations and Travel Logs vs. GPS-Enhanced Time-Location Data

The enhanced time-location database generated from logs, GPS and follow-up interview data significantly improved the amount and quality of time-location data collected through activity logs alone. This section compares the locations and trips reported in participant logs to those included in the final GPS-enhanced database. Although the GPS-enhanced time-location database included data for 131 "simultaneous" log-GPS tracking days of 47 participants, we only analyzed data for 103 days of 39 participants for this comparative analysis because log data was so limited or incomplete for 25 days that we could not compare it in a meaningful way to the final GPS-enhanced database. Log data was unavailable or unusable for 8 of these days and log data for the remaining 17 days was unclear or incomplete. Participants made errors such as listing multiple times and locations per row instead of listing only one time and location or travel mode per row such that patterns were largely indiscernible based solely on log data. Time-location data for these 25 days are included in the final GPS-enhanced database, however, since we used information participants reported on baseline interviews regarding the locations they visit frequently and available information from logs to inform our GPS location classification and follow-up interviews. We also excluded data for three additional days from the comparative analysis because participants remained at home indoors on these days, a pattern we verified in follow-up interviews.

To compare time-location data between participant logs and GPS-enhanced data we classified a location as a unique destination regardless of whether the participant was indoors, outdoors or in-vehicle at the location and a trip as the period between leaving one location and arriving at a second location regardless of the number of travel modes and/or waiting periods during travel between distinct locations. For instance, a mother's walk from-to home to drop her children at school included one trip to school, one location at school, and one trip back home. We consider her route to school as one trip even if she walked three blocks to a bus stop, waited for a bus, rode the bus, then exited the bus and walked the remaining two blocks to school. Her visit to school counted as one location even if she only stayed for a few seconds since this was a unique and purposeful destination as indicated by her travel patterns. Each time she returned to the school during the day counted as a unique location.

We used a generous definition of a "match" between logs and GPS-enhanced data in order to not disregard participant log information even when participants did not follow instructions to list only one time and location or travel mode per row. For instance, we compared data from some logs on which participants listed one time on a row then checked both a location (i.e., "Home") and a travel mode (i.e., "Walking"). In some cases participants also wrote "walk to home" in the "Notes" column. When comparing these data with GPS-enhanced data we assumed this participant had indicated one location and one trip on her log even though it was not always clear on the log whether the time listed referred to the time the participant started walking or when she arrived home. We also used a generous definition of a trip even when the participant did not report different modes or segments. For instance, some participants only listed one row for a trip (i.e., noting the time and checking "Transit") that GPS data reveal and follow-up data confirm was a trip with multiple walking and in-transit segments (which should have been listed on separate rows with separate times). Even though such participants only reported the initial segment of the trip, we considered this to be a "matched" trip between the log and GPS-enhanced data. Sequential trips and locations did not result in two "matches" unless both were explicitly indicated on a participant's log. For example, if a participant logged a vehicle trip near the time GPS data indicate she traveled home, this trip would be classified as a "match". Her arrival home would not be classified as a "matched" location unless she indicated her home destination by writing "drove home" or by checking "Home" on her log. Since our definition of a "matched" location or trip allowed participants to be in multiple microenvironments while at a location (i.e., Indoors, Outdoors) or while on a trip (i.e., Auto, Transit, Outdoors), we do not explicitly compare the microenvironments between participant logs and GPS-enhanced data.

Table 6.2.3.1 compares the locations and trips participants reported on logs to the locations and trips included in the GPS-enhanced data. The 39 participants in the comparative analysis occupied 1,105 locations and made 980 trips during the 103 days analyzed, or an average of about 11 locations and about 10 trips per day. Overall, about half (49%) of these locations and trips in the GPS-enhanced data were not recorded on participant logs. Over half (52%) of locations were not reported on logs and participants spent an average of over 3 hours in these unreported locations each day. Even though only about 21% of home arrivals were not listed on logs, this time at home (usually during the day) accounted for a good portion of time in unreported locations (about 1.5 hours). Participants did not report over 70% of trips to other residential locations, schools (including trips to drop-off and pick-up children), and retail and community locations. Combined these locations accounted for about 1.3 hours per day of time spent in unreported locations. Over three-quarters of locations occupied for less than 15 minutes were unreported and lasted just under 20 minutes (.3 hours). Although less than a quarter of locations occupied for 60 minutes or more were unreported, participant time in these locations lasted much longer, about 2.7 hours.

Just under half (47%) of participant trips in the GPS-enhanced data were not recorded on participant logs. These unreported trips lasted on average for about half an hour (0.6 hours) per day. About 54% of walking or biking trips were unreported (about 0.2 hours/day), about 44% of non-transit vehicle trips were unreported (about 0.4 hours/day), and about 19% of transit trips were unreported (about 0.02 hours/day). This lower rate of underreporting of transit trips could be in part due to the inclusive method we used to classify transit trips. That is, a participant's transit trip was a "match" with GPS data even if she only reported one segment of a longer trip with multiple connections (i.e., she only logged her walk to the bus stop or the time she boarded the first bus). About 58-59% of trips destined for home or other residential locations were unreported and totaled about 20 minutes (0.4 hours per day). About 47-52% of trips less than 15 minutes were unreported and also totaled about 20 minutes (0.4 hours per day)

We identified only two previous studies in the field of exposure assessment that analyzed the correspondence between activity log and GPS tracking. Phillips et al. 2001 compared the activity diaries and GPS tracking time-locations for 16 data collection trials for participants aged 21-55 years old in the Oklahoma Urban Air Toxics Study. Participants completed time-activity diaries by entering the start/end times of activities in sequence, a description of each activity and where it occurred, and location characteristics potentially associated with exposure. Five of the 16 trials included GPS data for most daily activities and at least one travel event in these five was not recorded on participant diaries. Unreported trips tended to be short trips that occurred as part of a longer series of errands.

Egulthun et al. 2007 compared the GPS-based time-locations of 31 children ages 3-5 years in Seattle, Washington with the patterns reported by their parents on diary timelines. Most participating children lived in lower-income households, about 40-45% lived in households with Spanish as the household language and/or had a parent who was Hispanic, and over 50% had a parent who stayed at home during the day. The timeline daily instrument required parents to circle the hours of the day that their children were Inside at Home, Inside at Work and School, Inside at Other, Outside at Home, Outside at Work and School, Outside at Other, and In Transit and to estimate the total hours and minutes in each of these time-locations at the end of the day. Parents misclassified time location patterns about 48% of the time. Parents in Spanish-speaking households were more likely to misreport time-locations than parents in English-speaking households. The rate of underreported locations and trips we found among HCTLS participants (49%) is very similar to the rate found by Egulthun et al. 2007 (48%) even though our data collection methods, comparison methods, and study population differed in significant ways.

Travel surveys conducted by state and regional governments have used GPS vehicle tracking to estimate the rate at which respondents to telephone recall surveys underreport travel. They suggest underreporting varies substantially across surveys, methods, and regions. These surveys typically ask respondents to recall the origin and destination addresses, the travel mode, the start and end time, and the duration and distance of each trip. Analysis of the Caltrans 2000-2001 California Statewide Household Travel Survey suggested that about 18% of trips identified though GPS tracking were not reported by respondents in Alameda (88 households) and San Diego Counties (111 households). Respondents in Sacramento County (93 households) did not report about 35% of trips (California Department of Transportation, 2002; Zmud and Wolf, 2003). Analysis of a subsample of the 2001/2 Los Angeles Regional Travel Study with simultaneous GPS vehicle monitoring indicated as many as 35% of respondent vehicle trips in Southern California were underreported (Zmud and Wolf, 2003; Bricka and Bhat, 2006). Only 10% of trips by respondents in the GPS-subsample of the 2004 Kansas City Regional Travel Survey (228 households) were unreported and analysis of 2004 Sydney Household Travel Survey which included in-person recall travel surveys with GPS tracking found that respondents reported about 7% of their trips (Stopher, 2007).

The rate of unreported trips among HCTLS participants (46%) was higher than the rates found in these GPS-based travel validation studies, a pattern that in part may be impacted by differences in sampling and classification methods:

(a) HCTLS participants were largely low-income, Hispanic women and homemakers, characteristics which may associate them with higher rates of underreporting. Respondents to travel surveys with less than a high school education, who were unemployed or who lived in lower-income households had higher rates of trip

Table 5.2.3.1. Unreported locations and travel – Logs vs. GPS-Enhanced Data

	Total Locations/Trips	Total Underreported Locations/Trips	Percent Underreported Locations/Trips	Av. Daily Locations/Trips	Av. Daily Underreported Locations/Trips	Av. Daily Location/Trip Hours	Av. Daily Underreported Location/Trip Hours
Total	**2,085**	**1,030**	**49%**	**20.2**	**10.0**	**24.0**	**4.0**
Locations/Arrivals							
Total	**1,105**	**571**	**52%**	**10.7**	**5.5**	**22.5**	**3.4**
By Location Type							
Home	403	86	21%	3.9	0.8	18.0	1.5
Other Residence	124	101	82%	1.2	1.0	0.6	0.3
School (Incl. drop-off/pick-up)	140	98	70%	1.4	1.0	1.0	0.5
Work	47	15	32%	0.5	0.1	1.1	0.3
Restaurant/Bar	52	30	58%	0.5	0.3	0.2	0.1
Retail and Community Locations	210	155	74%	2.0	1.5	0.9	0.5
Service (Medical, Bank, etc)	91	61	67%	0.9	0.6	0.3	0.1
Park/Recreation/Other	38	25	66%	0.4	0.2	0.4	0.2
By Duration at Location							
Under 5 minutes	233	203	87%	2.3	2.0	0.1	0.1
5-14 minutes	204	156	77%	2.0	1.5	0.3	0.2
15-59 minutes	209	109	52%	2.0	1.1	1.1	0.5
60 plus minutes	459	103	22%	4.5	1.0	21.0	2.7
Trips							
Total	**980**	**459**	**47%**	**9.5**	**4.5**	**1.5**	**0.6**
By Travel Mode							
Walking, Biking	333	181	54%	3.2	1.8	0.4	0.2
Vehicle Travel	616	272	44%	6.0	2.6	0.9	0.4
Transit Travel (Incl. Access/Waiting)	31	6	19%	0.3	0.1	0.2	0.0
By Travel Destination							
Home	290	171	59%	2.8	1.7	0.5	0.3
Other Residence	102	59	58%	1.0	0.6	0.1	0.1
School (Incl. drop-off/pick-up)	217	58	27%	2.1	0.6	0.3	0.1
Work	48	24	50%	0.5	0.2	0.1	0.0
Restaurant/Bar	50	26	52%	0.5	0.3	0.1	0.0
Retail and Community Locations	165	87	53%	1.6	0.8	0.2	0.1
Service (Medical, Bank, etc)	75	27	36%	0.7	0.3	0.1	0.0
Park/Recreation/Other	33	7	21%	0.3	0.1	0.1	0.0
By Trip Duration							
Under 5 minutes	373	193	52%	3.6	1.9	0.2	0.1
5-14 minutes	458	214	47%	4.4	2.1	0.6	0.3
15 plus minutes	149	52	35%	1.4	0.5	0.7	0.2

Note: Analysis based 103 days of 39 participants underreporting (Bricka and Bhat, 2006; California Department of Transportation, 2002; Zmud and Wolf, 2003).

(b) The HCTLS log and data collection methods differed significantly from that of telephone recall surveys which could include strategic respondent prompting. In-person recall travel surveys could potentially result in lower rates of trip underreporting (Stopher, 2007).

(c) GPS classification and processing methods vary across previous GPS-based travel validation studies and help explain the variation in underreporting rates. They generally used GIS and GPS time-sequence analysis to automate the identification of trips, and the thresholds used in trip detection impact underreporting rates. For instance, previous studies have used time thresholds of 2-5 minutes to classify vehicle stops/movement which resulted in underreporting rates ranging from 12%-31% (Bricka and Bhat, 2006). Previous studies have also used distance thresholds such as 200m to classify trip destinations (Bohte and Maat, 2009). Unlike previous studies, our analysis of HCTLS participant patterns was conducted manually through mapping and visual inspection of locations/routes which could reveal patterns not clear in automated GPS classification. We also used much shorter time thresholds to classify trips when justified by participant logs and routes. Furthermore, we used a distance threshold of 20-50 meters when possible to classify trip destinations. These refined methods likely resulted in the identification of more GPS-based trips and higher underreporting rates.

(d) Unlike most previous GPS-based travel validation studies, the GPS-enhanced data we compared to participant logs included insights from follow-up interviews with participants which we used to clarify whether unclear stops were trip destinations, to identify potential unreported locations, and to clarify travel mode and trip purpose.

5.2.4 Comparison of Time-Location Data

We compared the time-location patterns of HCTLS participants with comparable subgroups of the NHAPS survey which is a random sample telephone recall survey conducted by the United States' Environmental Protection Agency in the continental USA in 1992-1994. Subjects were contacted by phone, a household member was randomly sampled to participate, and this person was asked to recount their activities and location over the 24-hours of the previous day. For comparison with HCTLS, we analyzed the time-location patterns of two samples of adult NHAPS respondents between the age of 21 and 65: respondents in the continental United States (5,807) and a subset of these respondents who lived in California (628). NHAPS contains information at one-minute intervals with details for over 100 activity/location classifications. For the purpose of comparison, we aggregated HCTLS and NHAPS data into the location/activity types described in Table 6.2.3.1. Comparisons of time-location patterns between the HCTLS and NHAPS samples were made using an unpaired *t*-test with unequal variance.

Table 5.2.4.1. Description of location type categories used in analysis

Location type	**Description of locations included**
Indoors– Residential	Indoors at home or other residential locations
Indoors– Public, Service, School, Workplace	Indoors public buildings, office/work locations, laundromats, banks, medical facilities, schools, churches, community centers
Indoors– Retail, Restaurant/Bar	Indoors at shopping centers, grocery stores, dining locations or bars
Outdoors– Residential	Outdoors in yard or pool at home or other residence
Outdoors– Other	Outdoors on sidewalk, at a playground
Outdoors– Traveling or Waiting	Outdoors walking, biking, transit stop
Enclosed Vehicle– Traveling or Waiting	Traveling or waiting inside a passenger car, truck bus, train, airplane

5.2.5 Traffic and Truck Route Proximity

We examine the extent to which HCTLS participants spent time in proximity to heavily-travelled roadways and truck routes since vehicle-related air pollutants and related health impacts, including the prevalence of respiratory ailments and mortality, are highly localized within approximately 200 meters downwind of major roadways during the day (Zhu et al., 2002a; Zhu et al., 2002b; Sioutas et al., 2005; Lipfert and Wyzga, 2008; Hu et al., 2009). The measure of traffic proximity was developed based on traffic volume data from the 2005 Highway Performance and Monitoring System maintained by the California Department of Transportation. These data have been used and evaluated in previous health impact and environmental justice studies on the distribution and impacts of traffic (Ong et al., 2005; Houston et al., 2006). Consistent with previous studies, HCTLS participants who were within 200 meters of a roadway segment with an annual average daily traffic (AADT) of 50,000 or more vehicles per day was classified as being in a high-traffic area, participants who were within 200 meters of a roadway segment with AADT between 25,000 and 49,999 were classified as being in a medium-traffic area, and participants who were within 200 meters of a roadway with a maximum nearby AADT below 25,000 AADT were classified as being in a low-traffic area.

We also approximate exposure to heavy-duty diesel truck (HDDT) traffic since the harbor communities are heavily-impacted by port-related HDDT traffic (Houston, et al., 2008; Kozawa, et al., 2009). HDDT emit high levels of gaseous pollutants and diesel exhaust particulate matter which has been identified as a toxic air contaminant by the California Air Resources Board (California Air Resources Board, 1988). Residential proximity to roadways with high diesel vehicle volumes has been associated with higher prevalence of chronic respiratory ailments, reduced lung function and increased mortality (Brunekreef et al., 1997; Van Vliet et al., 1997; Adar and Kaufman, 2007). We measure proximity to truck routes using a novel traffic dataset for the study area previously documented (Wu et al., 2009) which consolidates data from numerous agencies and our original truck counts in the harbor communities (Houston et al., 2008) to identify truck volumes on major arterials and freeways. We classify HCTLS participants who were within 200 meters of a roadway with 5% or more HDDT traffic as being near a truck route.

5.2.6 In-Home Particulate Matter Monitoring

We obtained limited particulate matter (PM) measurements in the home of HCTLS participants during baseline and follow-up interviews using the instruments described in Table 6.2.5.1. A portable CPC instrument (TSI Model 3007) was used to collect particle number measurements and two portable DustTrak instruments (TSI Model 8520) were used to collect particle mass measurements.

Depending on the length of the training or interview, in-residence monitoring periods ranged from a minimum of 15 minutes to over an hour. One HCTLS researcher conducted the participant training or interview while a second researcher conducted the PM measurements, took limited pictures of the placements of instruments, drew a schematic of the residence noting the location of instruments, possible indoor PM sources (cooking, hot water heaters, evidence of smoking, open windows or doors, etc), heating/cooling status, activities that could potentially impact PM concentrations, and conditions relevant to the indoor penetration of outdoor air. As possible, instruments were placed away from open windows, away from fans or vents, away from potential indoor PM sources, and on a table or counter. These placements were in many cases impossible since many HCTLS residences were small and crowded with possessions or occupied by family members. We did not seek special accommodation for the placement or operation of the instruments because we did not want to distract from the primary purpose of our study which was to collect or clarify time-location data.

Table 5.2.6.1. Particulate Monitoring Instruments and Measurement Parameters

Instrument	**Measurement Parameter**	**Resolution**	**Response Time**	**Detection Limit**
TSI Portable CPC, Model 3007	UFP Count 10 nm-1um	1 particle/cm3	<9 s, for a 95% response	10 nm, <0.01 particles/cm3
TSI Model 8520 DustTrak	PM2.5	±0.001 mg/m3	10 s	0.001-100 mg/m3, 0.1-10 µm size range

5.3 Results

5.3.1 Time-Location Results

5.3.1.1 Diurnal Time Location Profiles

Figure 6.3.1.1 profiles the range of time-location patterns of HCTLS participants by illustrating the diurnal microenvironments, travel modes and proximity to traffic and truck routes of four HCTLS participants. Like most HCTLS participant days, Sample Participant A stayed close to home and structured her activities around transporting children to/from school, her own classes, and shopping. She left home about 7:30 and spent about 30 minutes in-vehicle dropping her children at two different nearby schools. She spent her morning indoors in an English class at a community center before traveling to pickup her first child midday. She then attended a 30-minute nutrition class and shopped for groceries before picking up her second child and returning home in the mid-afternoon. These trips were in a passenger vehicle and included two 30-minute in-vehicle waiting periods outside of schools. She walked to two nearby retail stores in the evening. She was only briefly in a medium traffic area while driving across Pacific Coast Highway and was in close proximity to a truck route in these times and while shopping in the midday and evening periods.

Sample Participant B used multiple travel modes both inside and outside of her neighborhood. She left home about 7:45 and rode in-vehicle about 30 minutes on major roadways and freeways to/from a 20-minute medical office visit in an adjacent city. At about 12:00 she traveled by bus to drop her child at daycare near a major truck route then rode with a friend for the 30-minute ride to eat lunch before riding back home. She traveled to/from childcare by bus in the afternoon then stayed at home indoors until she walked around her neighborhood for about 45 minutes for exercise at about 19:00. At about 20:30 she walked a couple blocks for a 40 minute visit a friend inside his/her residence before returning home.

Sample Participant C also balanced family, volunteer, and educational activities on her observation day. She walked two blocks from home to drop off her child at school near a major truck route just before 9:00 then drove about 10 minutes to attend a 2-hour community education and volunteer meeting inside a local church. After this meeting, she drove to attend community college classes from about 12:00 until 15:00, a location which is in close proximity to a medium-traffic roadway. After returning home, she made two in-vehicle shopping trips in the evening.

Unlike most HCTLS participants, Sample Participant D was male, lived alone near a major truck route, was employed full-time, and rode over 50 km to multiple destinations during the day for work to deliver/unload materials at multiple locations in Southern California. On the profile day, he left home for his first delivery at 6:05 and made brief stops for eating and shopping between deliveries until he returned home at about 13:30. He left home again in-vehicle around 14:00 to pick up someone at a medical faculty, eat at nearby restaurants, then spent time indoors and outdoors at a recreational facility for 2.5 hours. Afterwards, he stopped briefly by food and retail locations before returning home at about 22:00. He spent the majority of his day in close proximity to traffic because he lived within 200m of a truck route and traveled on medium- and high-traffic roadways most of the day.

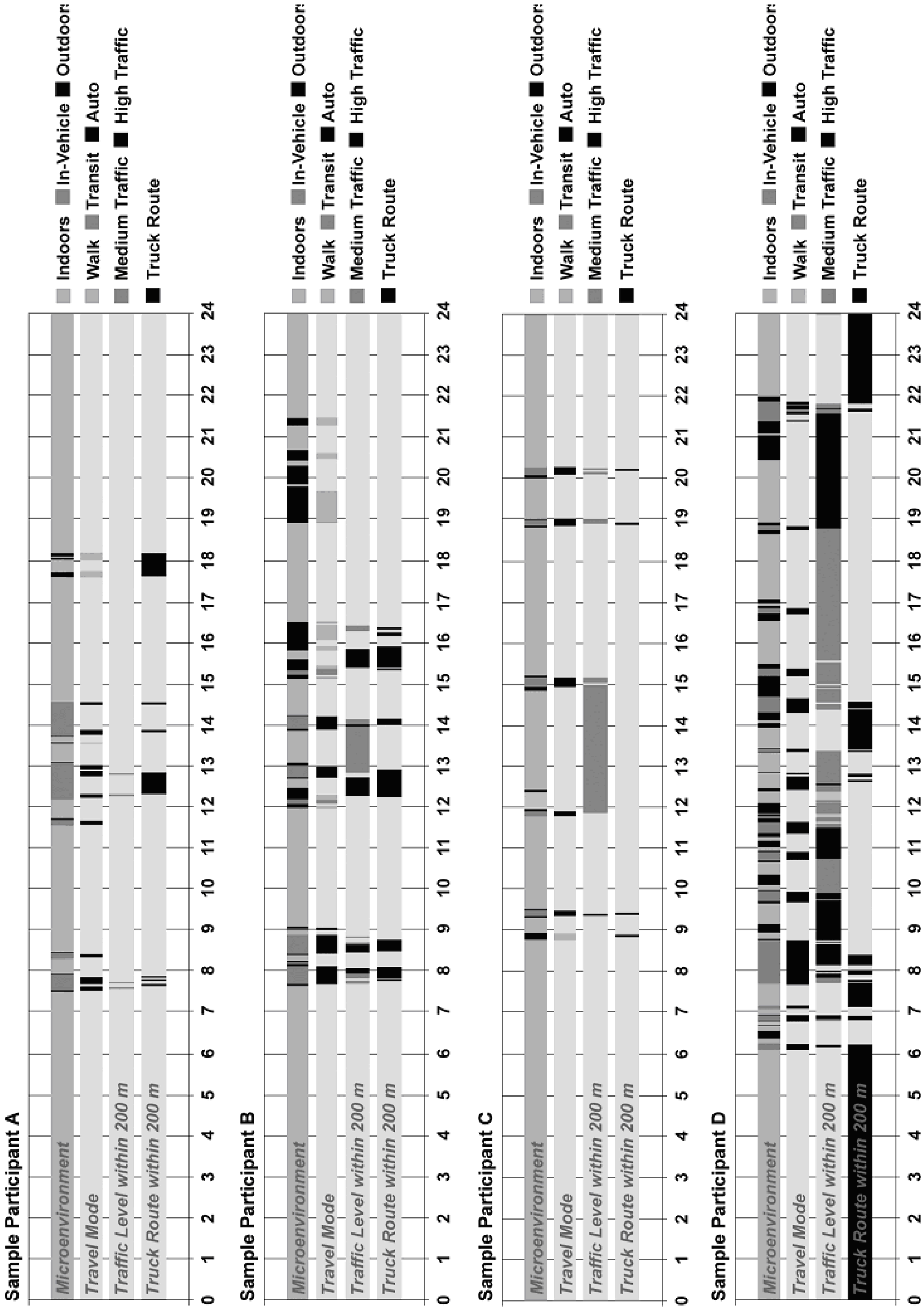


Figure 5.3.1.1. Sample HCTLS Time Location Patterns

5.3.1.2 Comparison of NHAPS and HCTLS Participants

Table 6.3.1.1 provides demographic and SES information on 5,807 respondents in the national NHAPS sample, 628 respondents in the California NHAPS sample, and 47 participants in the HCTLS sample. Although the harbor communities of Wilmington and western Long Beach were comprised of 65% Hispanic residents based on 2000 census data (Houston, Krudysz et al., 2008), the HCTLS sample was largely Hispanic (89%), female (85%), and foreign-born (81%) because we were most successful recruiting participants through community and health organizations and daytime education classes which targeted Spanish-speaking communities. In contrast, the NHAPS-Nation sample was 7% Hispanic and 54% female and the NHAPS-CA sample was 17% Hispanic and 49% female. The percentage of Hispanic residents in the study area has likely increased since the 2000 census given the California Department of Finance estimates that the number of Hispanic residents in Los Angeles County as a whole increased by about 14% between 2000 and 2007 and that their overall proportion of the population increased by about 3% during this time (California Department of Finance, 2009).

Only about 32% of HCTLS participants were employed compared to about 77% of all NHAPS-Nation respondents and 73% of female NHAPS-Nation respondents. Roughly three quarters of the HCTLS participants indicated they were homemakers and/or worked at home compared to about a quarter of NHAPS respondents who indicated they were unemployed. HCTLS participants were more likely to have less than a high school education than the NHAPS samples. Although comparable data are not available in NHAPS, over half of HCTLS participants indicated their annual household income was below $25,000.

5.3.1.3 Comparative Time-Location Patterns

HCTLS participants spent a significantly higher percentage of their day indoors than the NHAPS samples (89% vs. 87%) (Table 6.3.1.2). Of indoor microenvironments, HCTLS participants spent about 12% (~3 hours) more of their day inside residential locations, 5-6% (~1.5 hours) less of their day inside Public, Service, School, or Workplace locations, and about 3% (< 1 hour) less of their day inside Retail or Restaurant/Bar locations compared to the NHAPS samples.

HCTLS participants spent significantly less time outdoors than NHAPS-Nation and NHAPS-CA respondents (6% vs. 7-8%), mainly because they spent less time outdoors of residential locations. This difference could be due in part to differences in location classification methods given that we were unable to distinguish time on patios or outdoor spaces near buildings from indoor time due to GPS positional error. We generally classified HCTLS participant time after arrival and before departure at residential locations as indoors. Although there was no significant difference across samples in the percentage of time spent walking or biking outdoors or waiting outdoors for transit, HCTLS participants spent significantly less time inside an enclosed vehicle (5% vs. 8-9%), about 30 minutes less on average.

Table 5.3.1.1. Distribution of participants by background factors, NHAPS and HCTLS, Age 21-65

	NHAPS-Nation	NHAPS-CA	HCTLS
Time Location Days	5,807	628	131
Participants	5,807	628	47
Demographics			
% Female	54%	49%	85%
% 21-39 Years Old	50%	49%	47%
% 40-65 Years Old	50%	51%	53%
% Hispanic	7%	17%	89%
% Foreign-Born	NA	NA	81%
% Primary Language Spanish	NA	NA	77%
Work and School Status			
% Work Full or Part Time	77%	73%	32%
% Unemployed/Homemaker [i]	23%	26%	74%
Percent Attending School/College	NA	NA	34%
Educational Attainment			
% Less than High School	8%	5%	48%
% High School Degree	34%	28%	25%
% Some College or More	57%	67%	27%
Household Income			
Less than $25,000	NA	NA	53%
$25,000-$50,000	NA	NA	26%
50,000 or more	NA	NA	15%

NA- Not available

[i] The Unemployed/Homemaker category includes NHAPS respondents who were unemployed and HCTLS participants who were homemakers and/or worked at home.

Women in all samples spent a higher percentage of their day indoors than the samples as a whole. HCTLS female participants spent about 8-9% (~2 hours) more of their day inside residential locations and about 3% (< 1 hour) less of their day inside Retail or Restaurant/Bar locations compared to women in the NHAPS samples. Female HCTLS participants were not significantly different than women in the NHAPS samples in terms of time spent across all outdoor categories, but they did spent significantly less time outdoors at residential location (perhaps due to the methodological reasons described above) and significantly more time traveling outdoors than women in the NHAPS samples. They spent significantly less time in a vehicle than women in the NHAPS-Nation sample, but were not significantly different in their in-vehicle time than women in the NHAPS-CA sample. Interestingly, the relative time activity patterns of the Hispanic HCTLS and NHAPS sub-samples were largely similar to those of the samples as a whole, with the exception that Hispanic NHAPS respondents spent more time in-vehicle than the NHAPS respondents as a whole.

The time-location patterns were most similar between HCTLS participants who were homemakers or worked at home and unemployed respondents in the NHAPS samples. Although there was no significant difference across samples in time spent inside residential locations, homemaker HCTLS participants did spend significantly more time on average (~1 hour) inside Public, Service, School, or Workplace locations than the unemployed NHAPS samples. This may reflect that many HCTLS participants were volunteers and/or attended community education classes. Perhaps due to methodological differences, homemaker HCTLS participants spent significantly less time outside residential locations. Like the female subsamples, homemaker HCTLS participants were not significantly different than the unemployed NHAPS samples in terms of the percentage of the day spent traveling (7%).

5.3.1.4 Location Type by Time of Day

Figure 6.3.1.2 illustrates the location by time of day of all NHAPS-Nation adult respondents, unemployed NHAPS-Nation adult respondents, and HCTLS participants. HCTLS participant locations by time of day were most similar to unemployed NHAPS respondents. Over 90% of all three groups were indoors before 6:00 and after about 23:00 and roughly 75-80% all three groups were in an indoor location between about 8:00 and 18:00. The locations in which the samples spent indoor time varied substantially. As may be expected, NHAPS adults as a whole spent a much larger portion of their indoor time between 8:00 and 18:00 in Public Service, School, or Workplace locations than HCTLS participants and unemployed NHAPS respondents, who spent roughly 50% or more of their midday time indoors at residential locations. HCTLS participants appear to have spent less time outdoors at a residence and more time outdoors at other locations in the midday period than the NHAPS samples, but these differences may be partially due to differences in data collection and classification methods.

Although the HCTLS graph appears somewhat jagged due to the small sample size, its diurnal patterns are consistent with the time location profiles described above and the characteristics of the nonrandom HCTLS study population. There was a spike among HCTLS participants for those leaving home in-vehicle or walking between 7:00-8:00 when participants were typically taking household children to school. They spent a much larger portion of their time indoors at Public, Service, School, or Workplace locations between 8:00-15:00 than unemployed NHAPS respondents largely because they were involved in community classes and volunteer work at local schools and health education organizations. As may be expected their time in these locations drops at about 15:00 when they typically picked up their children from daycare and school. The slight increase in this location type between 18:00-20:00 is consistent with the fact that HCTLS often left home in the early evening for grocery or retail shopping.

Table 5.3.1.2. Mean percent of day (95% CI) in locations/activities, NHAPS and HCTLS, Age 21-65

Location type	HCTLS	NHAPS-Nation	NHAPS-CA
A. Time by location, All Adults Age 21-65	n=131	n=5,807	n=628
Indoors	**89.4 (88.1-90.6)*†**	**86.6 (86.2-87.0)***	**85.6 (84.5-86.8)†**
Residential	*77.5 (75.2-79.8)*†*	*65.6 (65.0-66.1)**	*66.1 (64.5-67.6)†*
Public, Services, School, Workplace	*9.9 (8.1-11.8)*†*	*16.0 (15.5-16.5)**	*14.6 (13.1-16.0)†*
Retail, Restaurant/Bar	*1.9 (1.5-2.4)*†*	*5.0 (4.8-5.3)**	*5.0 (4.3-5.7)†*
Outdoors	**5.9 (5.0-6.7)*†**	**7.1 (6.8-7.4)***	**8.1 (7.1-9.0)†**
Residential	*1.0 (0.8-1.3)*†*	*3.0 (2.9-3.2)**	*3.2 (2.6-3.8)†*
Other	*2.7 (2.0-3.4)*	*2.1 (1.9-2.3)*	*2.6 (2.0-3.2)*
Outdoors Traveling or Waiting[i]	*2.2 (1.7-2.6)*	*2.0 (1.8-2.2)*	*2.3 (1.8-2.9)*
Traveling or Waiting During Travel	**6.9 (6.1-7.8)*†**	**8.3 (8.0-8.6)***	**8.6 (7.8-9.4)†**
Outdoors Traveling or Waiting[i]	*2.2 (1.7-2.6)*	*2.0 (1.8-2.2)*	*2.3 (1.8-2.9)*
Enclosed Vehicle, Traveling or Waiting	*4.8 (3.9-5.7)*†*	*6.3 (6.1-6.5)**	*6.3 (5.7-6.9)†*
B. Time by location, Female	n=111	n=3,113	n=310
Indoors	**90.3 (89.1-91.5)†**	**89.3 (88.9-89.7)**	**87.9 (86.6-89.3)†**
Residential	*78.1 (75.6-80.5)*†*	*69.1 (68.4-69.8)**	*70.1 (68.0-72.2)†*
Public, Services, School, Workplace	*10.5 (8.4-12.5)**	*15.0 (14.4-15.6)**	*12.9 (11.0-14.7)*
Retail, Restaurant/Bar	*1.8 (1.3-2.3)*†*	*5.2 (4.9-5.5)**	*5.0 (4.1-5.9)†*
Outdoors	**5.1 (4.3-5.9)**	**4.9 (4.6-5.2)**	**6.4 (5.3-7.5)**
Residential	*0.9 (0.7-1.2)*†*	*2.6 (2.3-2.8)**	*2.7 (2.1-3.4)†*
Other	*2.0 (1.4-2.6)*	*1.4 (1.2-1.6)*	*2.3 (1.5-3.1)*
Outdoors Traveling or Waiting[i]	*2.2 (1.8-2.6)*†*	*1.0 (0.9-1.1)**	*1.3 (0.9-1.7)†*
Traveling or Waiting During Travel	**6.8 (5.9-7.7)**	**6.8 (6.5-7.0)**	**7.0 (6.2-7.8)**
Outdoors Traveling or Waiting[i]	*2.2 (1.8-2.6)*†*	*1.0 (0.9-1.1)**	*1.3 (0.9-1.7)†*
Enclosed Vehicle, Traveling or Waiting	*4.6 (3.6-5.6)**	*5.8 (5.6-6.0)**	*5.7 (5.0-6.3)*
C. Time by location, Hispanic	n=117	n=408	n=109
Indoors	**89.5 (88.2-90.8)*†**	**86.9 (85.5-88.3)***	**85.1 (82.0-88.2)†**
Residential	*78.6 (76.3-80.9)*†*	*65.5 (63.6-67.5)**	*65.1 (61.2-69.0)†*
Public, Services, School, Workplace	*9.2 (7.2-11.1)*†*	*16.4 (14.5-18.2)**	*14.9 (11.2-18.7)†*
Retail, Restaurant/Bar	*1.8 (1.3-2.2)*†*	*5.0 (4.1-6.0)**	*5.1 (3.5-6.7)†*
Outdoors	**6.1 (5.2-7.1)**	**6.2 (5.1-7.3)**	**8.2 (5.9-10.6)**
Residential	*1.0 (0.8-1.3)*†*	*2.5 (1.9-3.2)**	*3.1 (1.7-4.6)†*
Other	*2.8 (2.0-3.6)**	*1.7 (1.0-2.3)**	*2.3 (1.0-3.6)*
Outdoors Traveling or Waiting[i]	*2.3 (1.9-2.8)*	*2.0 (1.4-2.7)*	*2.8 (1.3-4.3)*
Traveling or Waiting During Travel	**6.7 (5.8-7.6)*†**	**8.9 (7.9-9.9)***	**9.5 (7.2-11.7)†**
Outdoors Traveling or Waiting[i]	*2.3 (1.9-2.8)*	*2.0 (1.4-2.7)*	*2.8 (1.3-4.3)*
Enclosed Vehicle, Traveling or Waiting	*4.4 (3.4-5.3)*†*	*6.8 (6.0-7.7)**	*6.7 (5.0-8.4)†*
D. Time by location, Unemployed/Homemaker[ii]	n=100	n=1,316	n=162
Indoors	**89.4 (88.1-90.8)*†**	**87.2 (86.4-87.9)***	**85.5 (83.2-87.8)†**
Residential	*78.7 (76.3-81.2)*	*78.3 (77.4-79.2)*	*78.0 (75.2-80.7)*
Public, Services, School, Workplace	*8.7 (6.9-10.5)*†*	*5.0 (4.5-5.6)**	*4.0 (2.7-5.3)†*
Retail, Restaurant/Bar	*2.0 (1.5-2.6)*†*	*3.8 (3.5-4.2)**	*3.6 (2.6-4.5)†*
Outdoors	**5.9 (5.0-6.8)*†**	**7.6 (6.9-8.2)***	**9.6 (7.7-11.6)†**
Residential	*1.1 (0.8-1.4)*†*	*4.4 (3.9-4.8)**	*4.8 (3.4-6.2)†*
Other	*2.4 (1.7-3.0)*	*2.0 (1.6-2.3)*	*3.2 (1.7-4.7)*
Outdoors Traveling or Waiting[i]	*2.4 (1.9-2.9)**	*1.3 (1.0-1.5)**	*1.6 (0.9-2.3)*
Traveling or Waiting During Travel	**7.1 (6.1-8.1)**	**6.6 (6.1-7.0)**	**6.5 (5.3-7.7)**
Outdoors Traveling or Waiting[i]	*2.4 (1.9-2.9)**	*1.3 (1.0-1.5)**	*1.6 (0.9-2.3)*
Enclosed Vehicle, Traveling or Waiting	*4.7 (3.6-5.8)*	*5.3 (4.9-5.7)*	*4.9 (3.9-5.9)*

[i] Time Outdoors Traveling or Waiting is included in both Outdoors and Traveling categories and tabulations.
[ii] The Unemployed/Homemaker category includes NHAPS respondents who were unemployed and HCTLS participants who were homemakers and/or worked at home.
* Denotes the difference between HCTLS and NHAPS-Nation is significant (unpaired *t*-test, $P<.05$)
† Denotes the difference between HCTLS and NHAPS-CA is significant (unpaired *t*-test, $P<.05$)

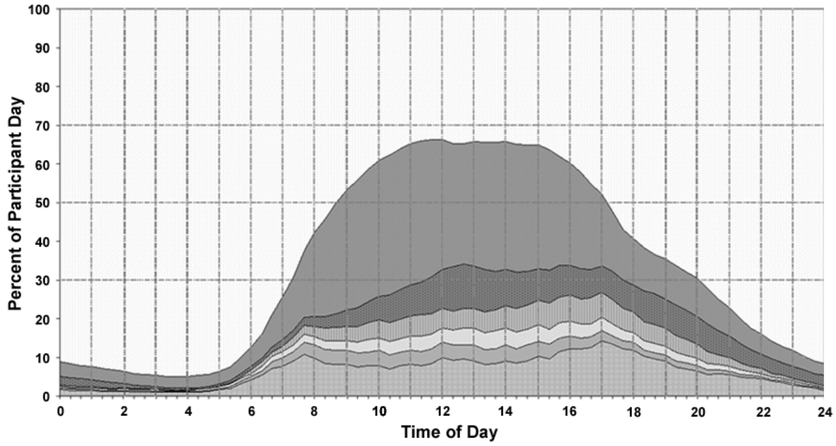
6.3.1.5. Proximity to Major Roadways and Truck Routes by Time of Day

The HCTLS study area is heavily impacted by as many as 16,000 HDDTs which serve the Ports of Los Angeles and Long Beach (Port of Long Beach and Port of Los Angeles, 2006), resulting in 500-600 HDDTs per hour on major arterials in the study area (Houston et al., 2008). This raises public health concerns given diesel-related pollutant concentrations of black carbon, nitric oxide, ultrafine particles, and particle-bound polycyclic aromatic hydrocarbons are frequently elevated within 200 m of these truck routes (Kozawa et al., 2009) and that residential proximity to major roadways and truck routes has been consistently associated with higher prevalence of respiratory ailments, reduced lung function, and increased mortality (Brunekreef et al., 1997; Van Vliet et al., 1997; Adar and Kaufman, 2007; Lipfert and Wyzga, 2008). Because previous studies did not have minute-by-minute time-activity and location data, they were unable to provide a 24-hour perspective on the extent to which subjects spent time in high traffic areas by location type.

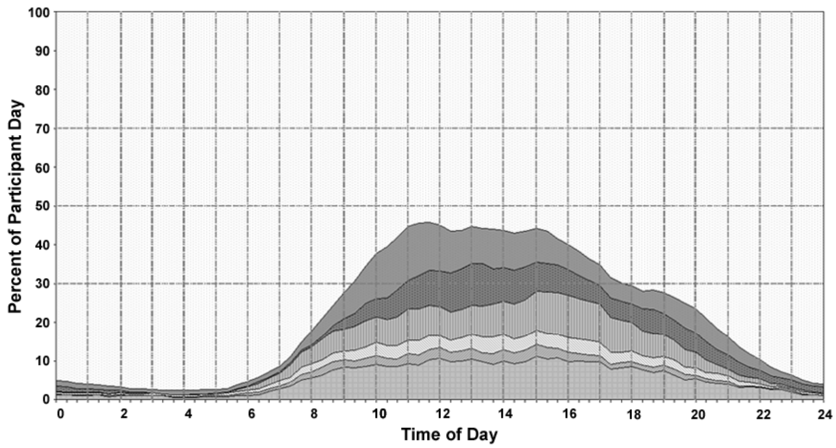
Although no HCTLS participants lived within 200m of high-traffic freeways, nine participants lived near a major arterial with medium-traffic. While these participants spent about 81% or over 19 hours of their day in a medium- or high-traffic area, HCTLS participants as a whole spent 21% of their day or about 5 hours near heavy traffic (Table 6.3.1.3). Section B of Figure 6.3.1.3 illustrates that the time HCTLS participants spent in heavy traffic areas changed very little over the course of the day and fluctuated between 20-25% between 8:00-22:00 except for when it approached 30% between 11:00-14:00. Our original counts of diurnal passenger and truck traffic on two major arterials in the study area (Houston et al., 2008) confirm that volumes were highest in these daytime periods, particularly in the evening commute period from about 15:00-18:00 (Figure 6.3.1.3, Section A).

Eight HCTLS participants lived within 200m of a truck route. These participants spent about 79% of their day or about 19 hours near a truck route compared to about 18% or about 4.3 hours for HCTLS participants as whole. This percentage stayed relatively constant over the course of HCTLS participant days (Figure 6.3.1.3, Section C).

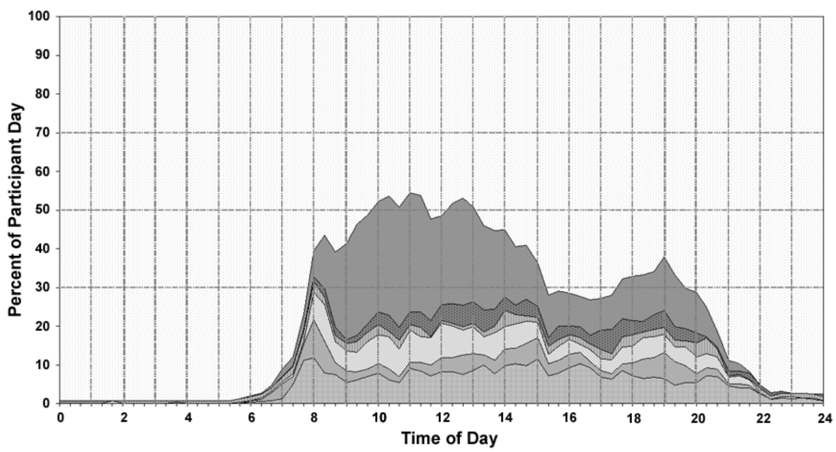
The amount of time spent in-roadways and on sidewalks could be associated with a substantial portion of overall exposure to vehicle-related pollution given that concentrations of vehicle-related pollutants are particularly high on arterials and freeways especially in periods of heavy traffic and acceleration at intersections (Westerdahl et al., 2007). In-vehicle may be the most important microenvironment for overall diesel exhaust particulate matter exposure (Fruin et al., 2004). Assuming a person spent 1.5 hours of a day in-vehicle, an amount consistent with the average in-vehicle time of the NHAPS-Nation sample in the current study, Fruin et al. estimate that about 33-45% of total exposure to ultrafine particles for residents of Los Angeles occurs while in-vehicle (Fruin et al., 2007) and about 30-55% of total exposure to diesel particulate matter for residents of California occurs while in-vehicle (Fruin et al., 2004).



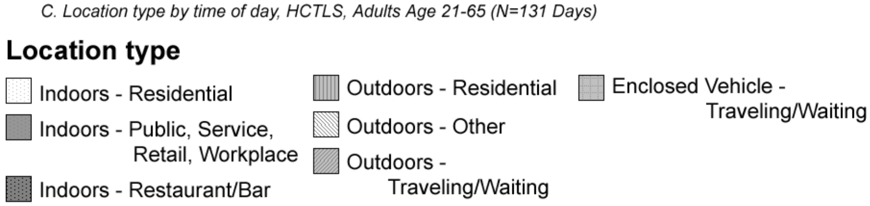
A. Location type by time of day, NHAPS-Nation, Adults Age 21-65 (N=5,807 Days)



B. Location type by time of day, NHAPS-Nation, Unemployed Adults Age 21-65 (N=1,316 Days)



C. Location type by time of day, HCTLS, Adults Age 21-65 (N=131 Days)



Note: Location pattern graphs represent 20-minute average for illustration purposes

Figure 5.3.1.2. Location type by time of day (NHAPS vs. HCTLS)

Table 5.3.1.3. Mean percent of day by locations/activities and proximity to major roadways traffic and heavy-duty diesel truck routes, HCTLS

Location type	Traffic volume within 200m			Truck route within 200m	
	Low Traffic	Medium Traffic	High traffic	No nearby truck route	Nearby truck route
Total	**79.1%**	**18.9%**	**2.0%**	**82.2%**	**17.8%**
Indoors	**80.8%**	**18.3%**	**0.9%**	**82.3%**	**17.7%**
Residential	*83.8%*	*15.8%*	*0.5%*	*81.7%*	*18.3%*
Public, Service, School, Workplace	*61.6%*	*35.7%*	*2.7%*	*89.4%*	*10.6%*
Retail, Restaurant/Bar	*55.5%*	*36.3%*	*8.2%*	*71.3%*	*28.8%*
Outdoors	**74.5%**	**19.6%**	**6.0%**	**85.0%**	**15.0%**
Residential	*72.0%*	*26.4%*	*1.6%*	*94.5%*	*5.6%*
Other	*64.5%*	*24.2%*	*11.3%*	*80.5%*	*19.5%*
Outdoors Traveling or Waiting	*88.1%*	*10.6%*	*1.4%*	*86.1%*	*13.9%*
Traveling or Waiting During Travel	**64.8%**	**23.0%**	**12.2%**	**80.1%**	**19.9%**
Outdoors, Traveling or Waiting	*88.1%*	*10.6%*	*1.4%*	*86.1%*	*13.9%*
Enclosed Vehicle, Traveling or Waiting	*54.9%*	*28.3%*	*16.8%*	*77.5%*	*22.5%*

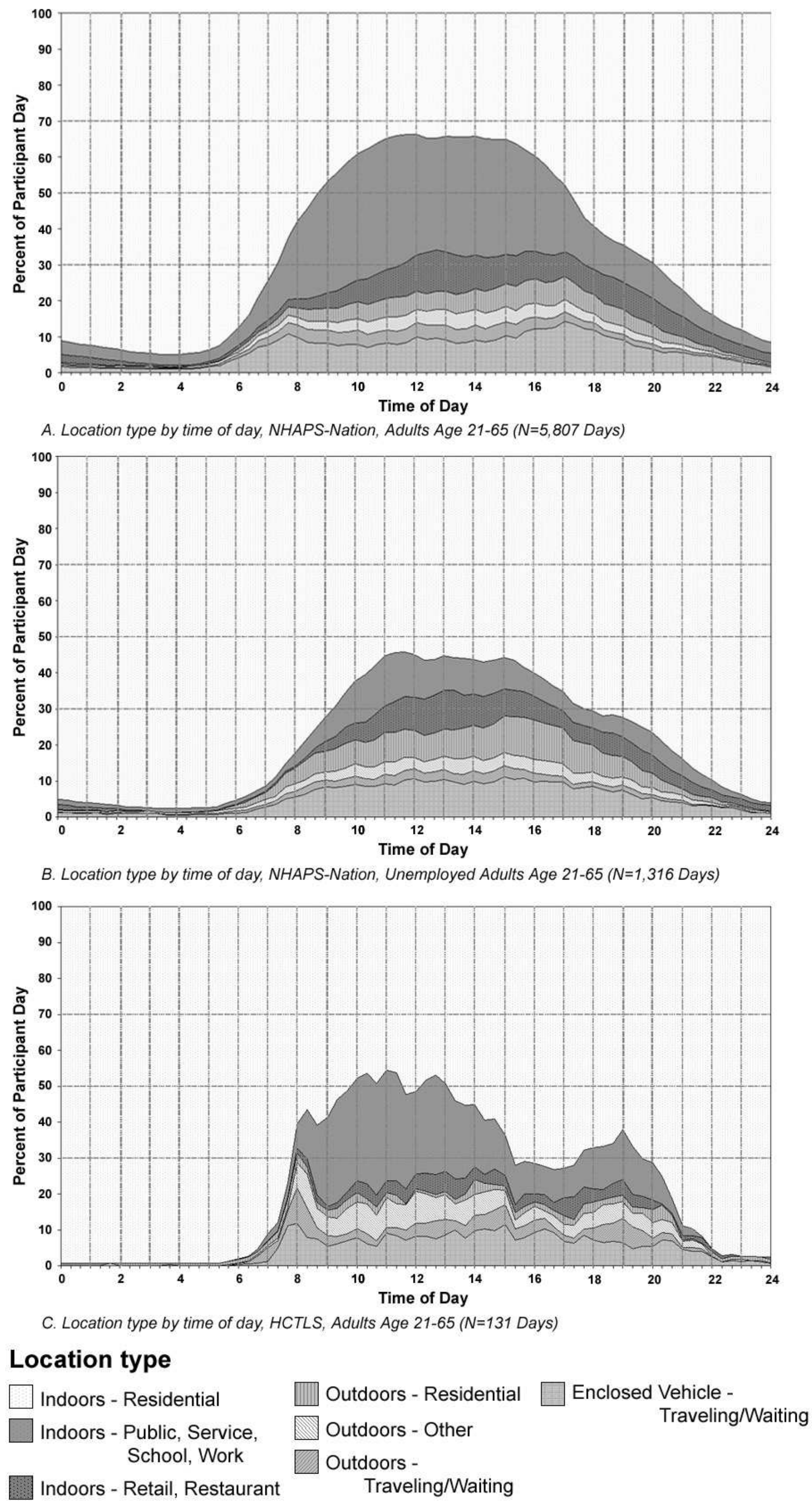
AADT=Annual Average Daily Traffic

Low traffic is <24,999 AADT; Medium traffic is 25,999-49,999 AADT; High traffic is >=50,000 AADT

In comparison, the HCTLS participants spent about 70 minutes on average per day in-vehicle (Table 3). Only about 45% (~30 minutes) of this in-vehicle time was in proximity to heavy traffic and only about 23% (~16 minutes) of this in-vehicle time was near a truck route (Table 6.3.1.3). Since HCTLS participants spent less time in-vehicle, their time in-vehicle may comprise a smaller proportion of their overall daily exposure to vehicle-related pollution than the levels described by Fruin and co-workers (Fruin et al., 2004; Fruin et al., 2007). HCTLS participants, however, who spent substantial time in-vehicle such as Sample Participant D profiled above may have experienced substantial in-vehicle exposures.

Time spent as pedestrians in heavy traffic areas is also of concern since higher activity rates are associated with higher rates of breathing and pollution exposure. Interesting, although HCTLS participants spent about 30 minutes per day on average traveling outdoors or waiting for transit, only 12% (~4 minutes) of this time on average was in close proximity to heavy traffic and only 14% (~4 minutes) of this time was near a truck route.

HCTLS participants spent about 2.4 hours per day on average in Public, Service, School, and Workplace locations. About 38% (~55 minutes) was spent near heavy traffic and about 11% (~16 minutes) of this time was near a truck route. Smaller retail, commercial, and public land uses tend to be located along major arterials in the study area and could potentially be an important microenvironment for overall exposure to vehicle-related air pollution. About 35% of the time participants spent in other outdoor locations was in proximity to heavy traffic and about 20% was near a truck route.



AADT=Annual Average Daily Traffic

Note: Location pattern graphs represent 20-minute average for illustration purposes

Figure 5.3.1.3. Diurnal study area traffic patterns and proximity to major roadways and truck routes

5.3.2 In-Home Particulate Matter Monitoring Results

5.3.2.1 In-Home Particle Count Measurements (CPC)

5.3.2.1.1 Background

A CPC instrument (TSI Model 3700) was used to measure particle number (PN) concentrations in the homes of HCTLS participants. A handful of previous studies have used the CPC 3007 to monitor indoor/outdoor particle concentrations across building types (schools, office buildings, residences) and in international locations with different levels of urbanization and traffic density.

Diapouli et al.'s (2007) monitoring in Athens in the cold periods of 2002 and 2003 observed 8-hour mean particle number concentrations as high as about 53,000 cm^{-3} inside a school and as high as about 39,000 cm^{-3} outside a school near heavy traffic. They observed 8-hour mean concentrations in classrooms ranging from about 2,000-25,000 cm^{-3}, with the highest values occurring in close proximity to a major roadway and the lowest in a rural area. They observed that "classroom concentrations decreased with the degree of traffic density and urbanization, indicating that, in the absence of significant indoor sources, vehicular emission influenced greatly the indoor concentration levels" (p. 132). Their 24-hour average indoor concentration over a week at the non-smoking residence monitored was about 13,000 cm^{-3}, and the highest 24-hour average of about 21,000 cm^{-3} occurred on the day the study room was cleaned. On non-cleaning days, the daytime mean (8:00–16:00) was about 10,000 cm^{-3}, the evening mean (16:00–00:00) was about 13,000 cm^{-3}, and the night mean (00:00–8:00) was about 17,000 cm^{-3}. They observed 8-hour daytime residential outdoor mean concentrations of about 14,000 cm^{-3}.

Monkkonen et al. (2004) report 1-hour average indoor PN concentrations in the range of 20,000-80,000 cm^{-3} based on CPC Model 3007 measurements in an urban household in Nagpur, India. They suggest high 1-hour concentrations in the daytime are associated with outdoor vehicular traffic as well as biomass or refuse burning. Daytime peaks were also explained by poor ventilation, large ceiling fans and small kitchens. Mean concentrations on a 24-hour period ranged from about 22,000-30,000 cm^{-3}.

Zhu et al. (2005) measured particle count concentrations in four two-bedroom apartments within 60 meters of the 405 Freeway in west Los Angeles, CA and found that outdoor counts were about 1.5–2 times higher than indoor particle count concentrations. Daytime counts (10am-5pm) inside downwind apartments were about 7,000-12,000 cm^{-3} and PN counts inside the one monitored upwind apartment was about 10,000 cm^{-3}. As they note, these measurements are not directly comparable to measurements using the CPC model 3007 used in the HCTLS since: "Outdoor measurements made by the P-Trak were usually 20–60% lower than those measured by the CPC, while indoor P-Trak measurements were typically 10–40% lower than CPC measurement. Thus, P-Trak results do not accurately reflect the smallest particles emitted by traffic and should be interpreted with caution**"** (p. 311). Also, during infiltration conditions with air exchange rates ranging from 0.31 to 1.11 h^{-1}, they found that the highest PN Indoor/Outdoor (I/O) ratios (0.6-0.9) were usually found for larger ultrafine particles (70–100nm), while the lowest I/O ratios (0.1–0.4) were observed for particulate matter of 10–20nm.

Kozawa et al. (2009) conducted on-roadway and near-roadway measurements of particle number concentrations in the HCTLS study area using a mobile platform which characterized the spatial distribution of pollution concentrations in communities adjacent to the Ports of Los Angeles and Long Beach. There measurements provide a frame of reference for understanding the range of outdoor PN concentrations near the homes of HCTLS participants. They found that concentrations can range generally from 20,000-40,000 cm^{-3} in areas within 150m-600m of major roadways but can reach peaks of 50,000-80,000 cm^{-3} in commercial and residential areas near roadways with substantial heavy duty diesel truck traffic.

Previous studies have also identified several indoor sources of particulate matter and suggest the extent to which they contribute to the overall indoor PN concentrations. Abt et al. (2000) monitored four single-family homes for 1-2 six day periods and found that cooking, cleaning, and the movement of people were the most important indoor particle sources in these homes. The impact of indoor sources was less pronounced when air exchange rates were higher. Under this condition indoor particle concentrations tracked outdoor levels more closely. Afshari et al. (2005) examined PN concentrations from various sources in a chamber study and found that cigarette smoke, candles, vacuum cleaners, irons, air-fresheners, and electric and gas stoves were important sources of indoor PM.

5.3.2.1.2 In-Home Particle Number Counts

As expected, we found substantial variation in the particle count concentrations in the homes of HCTLS participants. Appendix 6.6.2 provides a sample-specific summary of the average particle count concentrations measured using a CPC instrument in HCTLS participant homes during baseline and follow-up interviews. The appendix also provides general details on the building type, residence characteristics, sampling periods and time of day, and potential indoor sources. Monitoring was conducted for a minimum of 15 minutes to over an hour depending on the length of training and interviews, and occurred over multiple periods of the day from mid-morning to late evening because participant schedules and availability varied widely.

Recent studies have conducted stationary monitoring of PN concentrations in the HCTLS study communities and stress that outdoor ultrafine particle concentrations vary substantially over small spatial and temporal scales due to their short lifetimes and multiplicity of sources (Krudysz et al., 2007; Moore et al., 2007; Krudysz et al., 2009). This insight underscores the need for caution when interpreting the results of our PN concentrations in HCTLS participant residences, especially given that were only monitored concentrations for short periods of time.

Table 6.3.2.1 summarizes the average PN concentrations across all sampling periods, and groups them based on whether doors/windows were open or closed, whether potential indoor PM sources were apparent, and whether there were potential instrumentation problems. PN counts were collected during 94 in-home baseline and follow-up visits, out of 102 visits. The CPC (Model 3007) used detected particles ranging in size from 0.01 to 1 um and counts were collected as 1-minute averages. The CPC was not used during 8 visits because it required cleaning/maintenance. Monitoring lasted about 26 minutes on average.

Table 5.3.2.1. Summary of Average Particles cm^{-3} for All Monitoring Periods

	All	Closed doors/windows	Open Doors/windows All	Open Doors/windows No noticeable indoor source	Open Doors/windows Potential indoor source or CPC problems
Monitoring Periods	94	4	90	52	38
Average Minutes	26	43	24	25	24
Mean	***27,500***	***15,000***	***28,000***	***25,100***	***30,900***
Max	143600	26,300	143,600	66,400	143,600
Min	5,900	5,900	6,100	6,300	7,100
Median	23,100	13,800	23,300	22,100	25,000
SD	18,900	8,400	19,100	13,700	25,000

Note: Tabulations reflect on the average PN counts across monitoring periods.

Only 4 locations had all windows and doors closed, and the average PN concentration across these locations was about 15,000 cm^{-3}. The vast majority of sampling periods (90) occurred in a residence with at least one door or window open during monitoring period.

Fifty-two of these 90 monitoring periods with open windows/doors occurred when there was no noticeable potential indoor source. The average concentrations at these locations was about 25,000 cm^{-3} and the means at these locations ranged from about 6,000-66,000 cm^{-3}. Generally, these indoor concentrations were about 2-3 times the urban background levels PN concentration, assuming a range of urban backgrounds of 5000-20,000 cm^{-3} (Hu et al. Personal communication).

Of these 52 monitoring periods with open windows/doors and no noticeable potential indoor source, the highest average PN count (~66,000 cm^{-3}) was in a one-story duplex not near a major roadway and with no noticeable indoor source (other than a hot water heater). The second highest average PN count (~65,000 cm^{-3}) was in a 4th story apartment with a strong breeze from the I-710 freeway (150 meters from the apartment across a park) passing from the front door through the apartment to the patio door. Another high PN count (~79,000 particles/cm^{-3} average) occurred in the first 18 minutes of monitoring at a residence about 600m north of the major truck route Harry Bridges Boulevard just north of the Port of Los Angeles and about 500m east of I-110 freeway.

Thirty-eight monitoring locations had an open door/window and a noticeable indoor source (cooking, recent cooking re hot pot on stove, vacuuming, child playing on carpet next to instrument, ceiling or floor fan on) or potential CPC problem (low alcohol warning, or wick problems). The average concentrations at these locations was about 31,000 cm^{-3} and the means at these locations ranged from about 7,000 to 144,000 cm^{-3}. The highest average PN count (about 144,000 particles cm^{-3}) occurred in a residence where cooking was underway.

Although our PN monitoring was conducted at only a limited number of households for relatively short periods of time, we have grouped participant residences in southwestern Wilmington to examine the extent to which our limited results are consistent with the hypothesis that PN concentrations could be higher in residences near the major truck route Harry Bridges Boulevard just north of the Port of Los Angeles. These summary results include only monitoring periods during which there were open windows/doors and no noticeable indoor sources. We average concentrations across monitoring periods in residential "clusters" which are within about 40-60 meters of each other in southwestern Wilmington. Cluster averages are presented by their distance from the port complex starting with the one farthest from Harry Bridges Boulevard.

The first residential cluster of six monitoring periods, which was about 550-600m north of Harry Bridges Boulevard and about 450-500m east of I-110, had an average concentration of about 20,000 cm^{-3} and had average monitoring period concentrations of 7,000-44,000 cm^{-3}. The second residential cluster of five monitoring periods, which was about 400-470m north of Harry Bridges Boulevard and about 600m east of I-110, had an average concentration of about 29,000 cm^{-3} and had average monitoring period concentrations of 17,000-46,000 cm^{-3}. The third residential cluster of two monitoring periods (at a single residence), which was about 350m north of Harry Bridges Boulevard and about 220m east of I-110, had average monitoring period concentrations of about 15,000 cm^{-3} and 26,000 cm^{-3}. The fourth residential cluster of six monitoring periods, which was about 185-220m north of Harry Bridges Boulevard and about 475m east of I-110, had an average concentration of about 31,000 cm^{-3} and had average monitoring period concentrations of 7,000-58,000 cm^{-3}. Although caution should be used when interpreting these limited measurements, the observation that the average indoor particle concentration inside these residences with open windows/doors at clusters #1, #2, and #4 increases from 20,000 cm^{-3}, 29,000 cm^{-3} and 31,000 cm^{-3} is consistent with the hypothesis that PN concentrations could be higher in residences near the major truck route Harry Bridges Boulevard just north of the Port of Los Angeles.

5.3.2.2 In-Home Particle Mass Measurements (DustTrak)

Two DustTrak instruments (TSI Model 8520) were used to measure particulate matter mass concentration in the homes of HCTLS participants. Although continuous monitors such as DusTraks have several advantages in that they provide real-time data and characterization of short-term high concentrations (Babich et al. 2000; Chung et al. 2001), they can suffer from accuracy problems and are likely more useful on a relative rather than absolute basis (Ramachandran et al., 2000; Chung et al., 2001; Moosmuller et al., 2001; Yanosky and MacIntosh, 2001; Yanosky et al., 2002). Previous studies suggested DustTrak instrument overestimate the concentration of airborne particulate matter by factors of two or three compared to measurements from filter-based instruments such as the Harvard Impactor (Ramachandran et al., 2000; Chung et al., 2001; Yanosky et al., 2002) and that PM measurements collected using DustTrak instruments should be used as a relative measure (Fitz et al., 2003). Therefore, DustTrak measurements collected in the homes of HCTLS participants should be interpreted cautiously and be analyzed on a relative rather than an absolute basis. Appendix 6.6.3 details the particle mass measurements using DustTrak instruments in HCTLS participant homes during baseline and follow-up interviews.

5.4 Discussion

The HCTLS is first study to integrate participant-reported activity log and passive GPS tracking with follow-up interviews to document the time-location patterns of a low SES immigrant group in a major transportation and goods movement corridor. Participants were largely Hispanic women and homemakers and spent about 89% of their time indoors, about 5% of their time in enclosed vehicles, and about 6% of their time outdoors. Using these broad location categories, participant time-location patterns are were fairly consistent with those of adult respondents to previous random telephone recall surveys in California (Wiley et al., 1991), the United States (Klepeis et al., 2001), and Canada (Leech et al., 2002). Although many HCTLS participants were active volunteers and/or attended community education classes, they spent a significantly higher proportion of their time indoors at home than respondents to these previous surveys (78% vs. 63-66%). In this regards, HCTLS participants were most similar to unemployed adult respondents in the national NHAPS sample.

Participants did not report about half of the location/travel identified in the GPS-enhanced data, an important insight given we are aware of only two studies in exposure assessment which assess the correspondence between activity log and GPS tracking. Phillips et al. 2001 identified short unreported trips on activity logs during 16 GPS trials with participants aged 21-55 years old in the Oklahoma Urban Air Toxics Study. Egulthun et al. 2007 used GPS tracking to determine that parents of 31 children ages 3-5 years in Seattle, Washington misclassified time location patterns on diary timeline about 48% of the time, and that parents in Spanish-speaking households were more likely to misreport time-locations. Even though our methods and study population differed in significant ways, this rate is very similar to the underreporting rate among HCTLS participants (49%). Analysis of travel surveys from four California counties compared GPS vehicle tracking to travel diaries and suggested that respondents did not report 18-35% of vehicle trips (California Department of Transportation, 2002; Zmud and Wolf, 2003). In comparison, HCTLS did not report 44% of vehicle trips.

Integrated methods were particularly beneficial in classifying time-location patterns of HCTLS participants because log completeness varied due to limited literacy skills and the frequency with which participants recorded activities. When available, activity log details provided valuable information about activity times, location types, microenvironment characteristics, and travel mode details which were not always readily apparent by overlaying GPS data with highly-resolved areal photography and land use maps. When not available, we prompted participants to provide these details in follow-up interviews and queried participants to clarify activities observed in GPS data which were not on logs (usually short trips or stops on a longer trip). Integrated activity tracking methods provide opportunities for clarification and cross-verification not available in telephone recall surveys and log-only activity and travel tracking.

Like previous studies (Phillips et al., 2001; Egulthun et al., 2003; Rainham et al., 2008), we found that GIS provided a valuable tool for classifying patterns by enabling overlays of GPS locations on street, land use and areal photography data. Although we consistently determined participant arrival and departure from locations by mapping GPS data, we were unable to distinguish 10-20m shifts between indoor and outdoor microenvironments because of limited GPS positional accuracy inside or adjacent to some building types. Despite this difficulty in distinguishing outdoor time near buildings, integrated GPS tracking provides diurnal data on participant microenvironments and activities comparable to those identified in activity data based on traditional recall and log-only methods.

Although the time-location patterns of HCTLS participants were similar to those of other populations based on broad location categories, GPS activity databases when enhanced by log and follow-up data offer substantial improvements over these methods by providing a nearly continuous spatial database that can be used to model exposure on smaller time intervals based on proximity to pollution sources and concentrations over the course of the day. We demonstrate this benefit by examining the extent to which participants spent time in high traffic areas and near truck routes given vehicle-related air pollutants and related health impacts are highly localized downwind of major roadways. Relatively short periods in these areas and in-vehicle during heavy traffic and intersection accelerations could be associated with a large proportion of an individual's overall daily exposure to vehicle-related air pollution. Of the 5 hours that HCTLS participants spent in high traffic areas on average, about 3 hours were inside a residence and about 1 hour was inside a public, service, retail, or workplace location. Potential exposures in these locations could be of particular concern given that 50-70% of participants were inside a residence and 20-40% of participants were within a public, service, school, or workplace location in the morning, mid-day, and early evening periods when traffic on arterials and freeways tend to be at their highest levels. Although HCTLS participants spent slightly less time in-vehicle than the national NHAPS sample, their in-vehicle time could also potentially be an important microenvironment for overall exposure to vehicle-related pollutants since they spent 30 minutes of in-vehicle time in high-traffic areas. Further research is needed to evaluate the extent to which highly resolved GPS-enhanced time-location data can enhance exposure estimates.

We monitored PM mass and number inside HCTLS participant residences during baseline and exit interviews yielding the only data on indoor pollutant levels collected during the Harbor Community Monitoring Study. Although our sampling was very limited, we found substantial variation in the in-home particle count concentrations in the homes of HCTLS participants and patterns suggesting PN concentrations could be higher in residences near the major truck routes and the port complex. During 52 monitoring periods averaging 25 minutes conducted in residences with at least one open window or door and no noticeable potential indoor source, the average concentration using a TSI CPC Model 3007 was about 25,000 cm^{-3} and the means at these locations ranged from about 6,000-66,000 cm^{-3}. More extensive monitoring is needed to better understand indoor PM concentrations in communities in goods movement corridors and the relationship of outdoor and indoor air pollution concentrations.

Our experiences with participants reiterated that residents of port-adjacent communities are very concerned over the potential health effects of port- and truck-related air pollution. Many discussed family health problems such as persistent asthma which they attributed to air pollution and wanted to better understand the conditions under which they and their community are exposed to possible harm. Despite their concern and interest, residents seemed to have only general knowledge about the potential sources, dispersion patterns, and harmful impacts of air pollution. Effective interventions to reduce exposure in these communities will require not only more pollution and activity monitoring but also extensive public outreach and education so that harbor community residents can be more effective partners in developing and implementing policy and planning solutions to air pollution problems in their neighborhoods.

6.0 CONCLUSION AND RECOMMENDATIONS

This mobile platform based research has substantially expanded our understanding of the potential impacts of mobile source emissions on adjacent microenvironments, including near-roadway impact zones during the day; residential neighborhoods downwind of major roadways in the pre-sunrise hours; and neighborhoods downwind of general aviation airports such as the Santa Monica Airport. In all of these cases, there is the potential for human exposures to mobile source-related emissions that are elevated, perhaps highly elevated, compared with the exposures of people living outside such impact areas. In the following sections we present a summary of our key findings and mention some of their implications and our conclusions.

6.1.1 Near-Road Air Pollution Impacts Due to Goods Movement in Designated Impact Zones

In communities adjacent to the Ports of Los Angeles and Long Beach, which are heavily impacted by heavy-duty diesel truck traffic (HDDT), diesel-related pollutant concentrations such as black carbon, nitrogen oxide, ultrafine particles, and particle bound polycyclic aromatic hydrocarbons were frequently elevated two to six times within 150 m downwind of freeways (compared to more than 150 m) and up to two times within 150 m arterial roads with significant amounts of diesel traffic.

While wind direction was the dominant factor associated with downwind impacts, steady and consistent wind direction was not required to produce high impacts, which were usually observed whenever the wind direction placed a given area downwind of a major roadway for any significant fraction of time. This suggests that elevated pollution impacts downwind of freeways and of busy arterials are nearly constantly occurring on one side or the other of a busy roadway, depending on wind direction.

The diesel truck traffic in the area studied was high, with more than 2,000 trucks per peak hour on the freeway and two- to six-hundred trucks per hour on the arterial roads studied. These results suggest that similarly-frequent impacts occur throughout coastal zone urban areas in rough proportion to diesel truck traffic fractions, although more studies are needed in drier inland areas which may exhibit stronger radiation inversions. Thus, persons living or working near and downwind of busy roadways can have several-fold higher exposures to diesel vehicle-related pollution than would be predicted by ambient measurements at fixed-site monitoring networks which have been, established to characterize average pollutant concentrations over larger communities or regions.

6.1.2 Wide Area of Air Pollutant Impact Downwind of a Freeway During Pre-Sunrise Hours

We observed a wide area of air pollutant impact downwind of a freeway during pre-sunrise hours in both winter and summer seasons. In contrast, previous studies have shown much sharper air pollutant gradients downwind of freeways, with levels above background concentrations extending only 300 m downwind of roadways during the day and up to 500 m at night. In winter pre-sunrise hours, the peak ultrafine particle (UFP) concentration (~95,000 cm^{-3}) occurred immediately downwind of the freeway. However, downwind UFP concentrations as high as ~ 40,000 cm^{-3} extended at least 1,200 m from the freeway, and did not reach background levels (~15,000 cm^{-3}) until a distance of about 2,600 m. UFP concentrations were also elevated over background levels up to 600 m upwind of the freeway. Other pollutants, such as NO and particle-bound polycyclic aromatic hydrocarbons, exhibited similar long-distance downwind concentration gradients.

In contrast, air pollutant concentrations measured on the same route after sunrise, in the morning and afternoon, exhibited the typical daytime downwind decrease to background levels within ~300 m as found in earlier studies. Although pre-sunrise traffic volumes on the freeway were much lower than daytime congestion peaks, downwind UFP concentrations were significantly higher during pre-sunrise hours than during the daytime; UFP and NO concentrations were also strongly correlated with traffic counts on the freeway. We associate these elevated pre-sunrise concentrations over a wide area with a nocturnal surface temperature inversion, low wind speeds, and high relative humidity.

Observation of a wide air pollutant impact area downwind of a major roadway prior to sunrise has important exposure assessment implications since it demonstrates extensive roadway impacts on residential areas during pre-sunrise hours, when most people are at home.

6.1.3 Observation of Pollutant Concentrations Downwind of Santa Monica Airport

An impact area of elevated ultrafine particle (UFP) concentrations was observed extending beyond 660 m downwind and 250 m perpendicular to the wind on the downwind side of the Santa Monica Airport.

Aircraft operations resulted in average UFP concentrations elevated by factors of 10 and 2.5 at 100 m and 660 m downwind, respectively, over background levels. The long downwind impact distance (i.e. compared to nearby freeways at the same time of day) is likely primarily due to the large volumes of aircraft emissions containing higher initial concentrations of UFP than on-road vehicles. Aircraft did not appreciably elevate average levels of black carbons (BC), particle-bound polycyclic aromatic hydrocarbons (PB-PAH), although spikes in concentration of these pollutants were observed associated with jet takeoffs. Jet departures resulted in peak 60-second average concentrations of up to 2.2×10^6 cm^{-3}, 440 ng m^{-3}, and 30 µg m^{-3} for UFP, PB-PAH, and BC, respectively, 100 m downwind of the takeoff area. These peak levels were elevated by factors of 440, 90, and 100 compared to background concentrations.

Peak UFP concentrations were reasonably correlated (r^2=0.62) with fuel consumption rates associated with aircraft departures, estimated from aircraft weights and acceleration rates. UFP concentrations remained elevated for extended periods associated particularly with jet departures, but also with jet taxi and idle, and operations of propeller aircraft. UFP measured downwind of SMA had a median mode of about 11nm (electric mobility diameter), which was about a half of the 22 nm median mode associated with UFP from heavy duty diesel trucks.

The observation of highly elevated ultrafine particle concentrations in a large residential area downwind of this local airport has potential health implications for persons living near general aviation airports.

6.1.4 Time-Location Study in Port-Adjacent Communities

The Harbor Communities Time Location Study (HCTLS) integrated traditional recall diary activity logs and with GPS tracking and follow-up "prompted recall" surveys to document the patterns on 131 weekdays of 47 adult residents of communities adjacent to the Ports of Los Angeles and Long Beach, areas heavily impacted by diesel truck traffic. The enhanced time-location database generated from logs, GPS and follow-up interview data significantly improved the amount and quality of time-location data collected through recall diary activity logs alone. Overall, about half (49%) of participant locations and trips in the GPS-enhanced data were not recorded on participant diary logs. Participants spent an average of over 3 hours per day in unreported locations and about half an hour per day on unreported trips.

HCTLS participants were largely low-income, Hispanic women and homemakers and on average spent about 89% of their day indoors and about 7% traveling. Similar to unemployed National Human Activity Pattern Survey (NHAPS) respondents of the same age, HCTLS participants spent about 78% of their day within a residence and about 5% in a vehicle. HCTLS participants, however, spent slightly more of their day walking or biking (2%) and inside public, service, school, or workplace locations (9%). About one fifth lived near a heavily-travelled roadway or truck route and may have experienced heightened exposures to vehicle-related pollution. Participants spent about 5 hours per day on average near heavy traffic (about 3 hours inside a residence, 1 hour inside a public, service, school, or workplace location, and 30 minutes in-vehicle).

We also conducted very limited sampling of PM mass and number inside HCTLS participant residences during baseline and exit interviews, yielding data on indoor particulate concentrations, the only data on indoor pollutant levels collected during the Harbor Community Monitoring Study. As expected, we found substantial variation in the in-home particle count concentrations in the homes of HCTLS participants. During 52 monitoring periods averaging 25 minutes conducted in residences with at least one open window or door and no noticeable potential indoor source, the average concentration using a TSI CPC Model 3007 was about 25,000 cm^{-3} and the means at these locations ranged from about 6,000 to 66,000 cm^{-3}.

6.2 Recommendations

The application of an electric-vehicle mobile platform to obtaining highly resolved spatial and temporal air pollutant data for both gases and particulates in three important locations in the California South Coast Air Basin led to the novel research findings described above. These discoveries illustrate the utility and power of using such a mobile platform across days, seasons and geographical areas to elucidate effects that cannot be observed by widely spaced, fixed-site monitoring networks and clearly this powerful experimental tool should continue to be employed to investigate air pollutant impacts on highly resolved spatial and temporal scales.

Our time-location study demonstrated the value of a novel “prompted recall” approach to characterizing time-activity patterns for port community residents, where use of GPS records allowed identification of the limitations of the traditional recall diary approach. The results from this time-activity study, when coupled with the extensive air pollutant monitoring data from the HCMS, can provide valuable data for subsequent modeling of port community resident exposures.

Given the large body of data showing increased morbidity and mortality for people living in proximity to mobile source emissions, e.g. roadways with heavy duty diesel truck traffic, it is important to investigate in future research the full implications of the exposures identified in the present research, including modeling of both individual and population-based exposures, and potentially epidemiological studies.

Policies to reduce and/or minimize the exposures identified here should be pursued. This includes measures to further reduce emissions from mobile sources of all kinds, especially those of HDDT and high-emitting gasoline vehicles; reducing the number of emitting vehicles through lower VMT strategies and encouragement of electric vehicles; and adoption of land-use policies that restrict or minimize the location of residential neighborhoods immediately adjacent to major line sources and sources such as general aviation airports, rail yards and shipyards at large ports.

7.0 RECOMMENDATIONS FOR FUTURE RESEARCH

Based on the novel results from our present mobile platform project a number of extensions and refinements of this research are can be suggested.

Given the potential importance of our observation of a much wider area of impact downwind of a major freeway in the pre-sunrise hours, it is important to test whether this finding can be generalized from a single freeway to other roadways, conditions and locations in Southern California. Candidate locations for testing our hypothesis, that the wider area of impact in the pre-sunrise period should be a universal phenomenon for comparable meteorological conditions, include the Ports area near the coast, further inland near downtown Los Angeles, and also in the Eastern part of the Air Basin where day-night temperature variations are large. These locations should be chosen to investigate a wider range of geographic settings and accompanying meteorological conditions, as well as to complement other goals of on-going mobile platform studies planned by the ARB. Freeway geometries (above or below grade, etc.) should also be investigated separately, as this may be a major (complex) factor in determining impact areas. Further investigation in the evening hours is also needed.

Mixing in the lowest layer of the atmosphere is central to characterizing impact areas surrounding freeways in the early morning. All previous MP studies, including this one, have had the capability only to measure surface winds, temperature and relative humidity when the vehicle is stopped, and temperature and RH when it is moving. In addition it has been possible to retrieve vertical temperature structure data collected by the SCAQMD at larger airports throughout the air basin. These data generally begin at about 130 m as its lowest edge, and have good but not perfect temporal coverage and fairly widely dispersed spatial coverage. Clearly, local vertical thermal structure and wind data would be very useful especially for the analysis of pre-sunrise data. A tethered balloon system could be used to measure vertical temperature structure and other meteorological parameters (wind speed, pressure, and relative humidity) in the lowest layer of the atmosphere. The use of tethered balloons to determine the near ground temperature structure of the atmosphere would be an important new capability for this type of research.

In view of the attention being given to the Boyle Heights area by a wide range of state and regional organizations, and our findings of elevated pollutant concentrations in the BH community, it would be of interest to conduct further measurements within the BH area, including at a new housing developments built recently under the administration of the Housing Authority of the City of Los Angeles. Similarly, additional measurements in the Port area at a new housing development immediately adjacent to the ports would be of interest.

Given the efficacy we have demonstrated for use of GPS devices in obtaining time-location data related to air pollutant exposure, compared with traditional recall diary methods, further studies could be conducted to refine and expand the methods we developed in the Harbor Community Time-Location Study. In particular, the ability to transmit time-location data obtained with a GPS-equipped cell phone, rapidly map and classify activity and location patterns, and administer follow-up surveys about unclear patterns, would enhance data collection and could lead to much larger scale studies involving large numbers of participants.

It is important to recognize that exploiting the full utility of the air pollutant monitoring data obtained during the HCMS and other similar studies, for example in modeling population-based exposures, requires a robust understanding of the time-activity of individuals living in areas in which the air monitoring is conducted. Yet such time-activity data have typically been costly and challenging to acquire and hence are very limited in availability. A transition to automated, electronic capture of time-location behavior from GPS-equipped cell phones programmed to transmit the resulting data could greatly expand time-activity databases in a cost-effective manner.

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9.0 INVENTIONS REPORTED AND COPYRIGHTED MATERIAL PRODUCED

None

10.0 GLOSSARY OF TERMS, ABBREVIATIONS AND SYMBOLS

ARB	California Air Resources Board
BC	black carbon
CENS	Center for Embedded Network Sensing (UCLA)
CO	carbon monoxide
CO2	carbon dioxide
DOLA	downtown Los Angeles
DPM	diesel particulate matter
GPS	global positioning system
HCMS	Harbor Community Monitoring Study
MP	mobile platform
NO	nitric oxide
NO2	nitrogen dioxide
NOx	oxides of nitrogen
NOAA	National Oceanic and Atmospheric Administration
PAH	polycyclic aromatic hydrocarbons
PB-PAH	particle bound PAH
PDT	Pacific Daylight Time
PIU	Particle Instrument Unit
PM	particulate matter
PM2.5	particulate matter less than 2.5 um in diameter
PR	prompted recall
SCAQMD	South Coast Air Quality Management District

SCPCS	Southern California Particle Center and Supersite
SMA	Santa Monica airport
SoCAB	South Coast Air Basin
T/A	time-activity
T/L	time-location
UCLA	University of California, Los Angeles
UFP	ultrafine particles
UTM	Universal TransMercator
UV	Ultra-violet
WLA	west Los Angeles

11.0 APPENDICES

11.1 <u>Participant-Level Time Location Pattern Summaries</u>

Participant 202:

Profile: Female, Hispanic, between 40-65 years old, prefers Spanish, completed B.A. or higher

Household Composition: No young children (<5), two older children (6-17), four adults (18-65), no seniors (>65)

Work and Transportation: Works at home and away from home part time, one household cars

Table A. Hours and Percent of Day by Microenvironment, Travel Mode and Proximity to Traffic and Truck Routes

	Day 1		Day 2		Day 3	
	Hours	**%Time**	**Hours**	**%Time**	**Hours**	**%Time**
Microenvironment						
Indoors	22.8	94.9%	20.6	85.9%	20.8	86.7%
Outdoors	0.7	2.9%	2.0	8.4%	1.1	4.6%
In-Vehicle	0.5	2.2%	1.4	5.7%	2.1	8.8%
Travel & Mode						
Not Traveling	23.1	96.4%	21.8	91.0%	21.8	90.8%
Walking	0.3	1.4%	1.2	5.0%	0.2	0.8%
Biking	0	0.0%	0.0	0.0%	0.0	0.0%
Transit Travel	0	0.0%	0.2	0.7%	0.4	1.6%
Vehicle Travel	0.5	2.2%	0.8	3.3%	1.6	6.7%
Traffic Level within 200m						
Low	3.3	13.7%	2.5	10.6%	3.4	14.2%
Medium	20.7	86.3%	21.3	88.7%	17.9	74.4%
High	0	0.0%	0.2	0.8%	2.7	11.4%
Truck Route within 200m						
No Nearby Truck Route	24	100.0%	23.6	98.5%	18.8	78.5%
Nearby Truck Route	0	0.0%	0.4	1.5%	5.2	21.5%

Table B. Unique Trips by Destination Type

Participant 204:

Profile: Female, Hispanic, between 40-65 years old, prefers Spanish, completed high school

Household Composition: No young children (<5), two older children (6-17), one adult (18-65), no seniors (>65)

Work and Transportation: Student / working part time, no household car

Table A. Hours and Percent of Day by Microenvironment, Travel Mode and Proximity to Traffic and Truck Routes

	Day 1		Day 2		Day 3	
	Hours	**%Time**	**Hours**	**%Time**	**Hours**	**%Time**
Microenvironment						
Indoors	19.8	82.3%	21.8	90.7%	22.5	93.9%
Outdoors	2.7	11.3%	1.2	4.8%	0.6	2.6%
In-Vehicle	1.5	6.3%	1.1	4.5%	0.8	3.5%
Travel & Mode						
Not Traveling	22.4	93.2%	22.2	92.6%	23.0	95.9%
Walking	0.1	0.6%	0.7	3.0%	0.2	0.6%
Biking	0	0.0%	0.0	0.0%	0.0	0.0%
Transit Travel	0	0.0%	0.0	0.0%	0.0	0.0%
Vehicle Travel	1.5	6.2%	1.1	4.5%	0.8	3.5%
Traffic Level within 200m						
Low	17.3	72.2%	18.6	77.5%	20.5	85.3%
Medium	6.2	25.6%	5.3	22.1%	3.5	14.6%
High	0.5	2.1%	0.1	0.5%	0.0	0.2%
Truck Route within 200m						
No Nearby Truck Route	22.1	91.9%	23.8	99.0%	23.8	99.3%
Nearby Truck Route	1.9	8.1%	0.2	1.0%	0.2	0.7%

Table B. Unique Trips by Destination Type

	Day 1					Day 2					Day 3				
Description	**Total**	**Walking**	**Biking**	**Transit**	**Vehicle**	**Total**	**Walking**	**Biking**	**Transit**	**Vehicle**	**Total**	**Walking**	**Biking**	**Transit**	**Vehicle**
Total	**10**	**2**	**0**	**0**	**8**	**10**	**3**	**0**	**0**	**7**	**7**	**2**	**0**	**0**	**5**
Home	**4**	1	0	0	3	**4**	1	0	0	3	**3**	1	0	0	2
Work	**0**	0	0	0	0	**0**	0	0	0	0	**0**	0	0	0	0
Education	**2**	0	0	0	2	**2**	0	0	0	2	**2**	0	0	0	2
Volunteer	**1**	0	0	0	1	**0**	0	0	0	0	**0**	0	0	0	0
Pickup-Dropoff	**3**	1	0	0	2	**1**	1	0	0	0	**1**	1	0	0	0
Dining/Eating	**0**	0	0	0	0	**0**	0	0	0	0	**0**	0	0	0	0
Shopping/Retail	**0**	0	0	0	0	**0**	0	0	0	0	**1**	0	0	0	1
Services	**0**	0	0	0	0	**1**	0	0	0	1	**0**	0	0	0	0
Recreational/Exercise	**0**	0	0	0	0	**2**	1	0	0	1	**0**	0	0	0	0
Residential Visit	**0**	0	0	0	0	**0**	0	0	0	0	**0**	0	0	0	0
Community/Public	**0**	0	0	0	0	**0**	0	0	0	0	**0**	0	0	0	0

Participant 205:

Profile: Female, Hispanic, between 21-39 years old, prefers Spanish, completed less than high school

Household Composition: One young child (<5), four older children (6-17), two adults (18-65), no seniors (>65)

Work and Transportation: Student and working, no household cars

Table A. Hours and Percent of Day by Microenvironment, Travel Mode and Proximity to Traffic and Truck Routes

	Day 1		Day 2	
	Hours	%Time	Hours	%Time
Microenvironment				
Indoors	17.5	72.9%	23.3	97.1%
Outdoors	5.6	23.3%	0.5	2.1%
In-Vehicle	0.9	3.8%	0.2	0.7%
Travel & Mode				
Not Traveling	22.5	93.8%	23.7	98.9%
Walking	0.6	2.4%	0.1	0.3%
Biking	0	0.0%	0.0	0.0%
Transit Travel	0.6	2.4%	0.2	0.7%
Vehicle Travel	0.3	1.4%	0.0	0.0%
Traffic Level within 200m				
Low	5.1	21.2%	0.3	1.5%
Medium	18.9	78.8%	23.7	98.5%
High	0	0.0%	0.0	0.0%
Truck Route within 200m				
No Nearby Truck Route	22.1	92.2%	24.0	100.0%
Nearby Truck Route	1.9	7.8%	0.0	0.0%

Table B. Unique Trips by Destination Type

	Day 1					Day 2				
Description	**Total**	**Walking**	**Biking**	**Transit**	**Vehicle**	**Total**	**Walking**	**Biking**	**Transit**	**Vehicle**
Total	**14**	**5**	**0**	**5**	**4**	**3**	**1**	**0**	**2**	**0**
Home	**4**	1	0	1	2	**2**	1	0	1	0
Work	**0**	0	0	0	0	**0**	0	0	0	0
Education	**0**	0	0	0	0	**0**	0	0	0	0
Volunteer	**2**	0	0	1	1	**0**	0	0	0	0
Pickup-Dropoff	**7**	4	0	3	0	**1**	0	0	1	0
Dining/Eating	**0**	0	0	0	0	**0**	0	0	0	0
Shopping/Retail	**0**	0	0	0	0	**0**	0	0	0	0
Services	**0**	0	0	0	0	**0**	0	0	0	0
Recreational/Exercise	**1**	0	0	0	1	**0**	0	0	0	0
Residential Visit	**0**	0	0	0	0	**0**	0	0	0	0
Community/Public	**0**	0	0	0	0	**0**	0	0	0	0

Participant 206:

Profile: Female, Hispanic, between 40-65 years old, prefers Spanish, completed less than high school

Household Composition: No young children (<5), two older children (6-17), two adults (18-65), no seniors (>65)

Work and Transportation: Student and homemaker, no household cars

Table A. Hours and Percent of Day by Microenvironment, Travel Mode and Proximity to Traffic and Truck Routes

	Day 1		Day 2	
	Hours	%Time	Hours	%Time
Microenvironment				
Indoors	22.7	94.5%	22.6	94.2%
Outdoors	1.3	5.5%	1.4	5.6%
In-Vehicle	0	0.0%	0.0	0.1%
Travel & Mode				
Not Traveling	22.9	95.4%	23.0	95.9%
Walking	0.2	0.9%	0.5	2.2%
Biking	0.9	3.6%	0.4	1.7%
Transit Travel	0	0.0%	0.0	0.0%
Vehicle Travel	0	0.0%	0.0	0.1%
Traffic Level within 200m				
Low	24	100.0%	24.0	99.8%
Medium	0	0.0%	0.0	0.2%
High	0	0.0%	0.0	0.0%
Truck Route within 200m				
No Nearby Truck Route	24	100.0%	24.0	100.0%
Nearby Truck Route	0	0.0%	0.0	0.0%

Table B. Unique Trips by Destination Type

	Day 1					Day 2				
Description	**Total**	**Walking**	**Biking**	**Transit**	**Vehicle**	**Total**	**Walking**	**Biking**	**Transit**	**Vehicle**
Total	**10**	**2**	**8**	**0**	**0**	**9**	**5**	**3**	**0**	**1**
Home	**4**	1	3	0	0	**3**	2	1	0	0
Work	**0**	0	0	0	0	**0**	0	0	0	0
Education	**0**	0	0	0	0	**1**	0	0	0	1
Volunteer	**0**	0	0	0	0	**0**	0	0	0	0
Pickup-Dropoff	**2**	1	1	0	0	**2**	2	0	0	0
Dining/Eating	**0**	0	0	0	0	**0**	0	0	0	0
Shopping/Retail	**2**	0	2	0	0	**1**	0	1	0	0
Services	**0**	0	0	0	0	**1**	0	1	0	0
Recreational/Exercise	**0**	0	0	0	0	**1**	1	0	0	0
Residential Visit	**2**	0	2	0	0	**0**	0	0	0	0
Community/Public	**0**	0	0	0	0	**0**	0	0	0	0

Participant 207:

Profile: Female, Hispanic, between 40-65 years old, prefers Spanish, completed less than high school

Household Composition: No young children (<5), three older children (6-17), two adults (18-65), no seniors (>65)

Work and Transportation: Works at home and homemaker, two household cars

Table A. Hours and Percent of Day by Microenvironment, Travel Mode and Proximity to Traffic and Truck Routes

	Day 1		Day 2		Day 3	
	Hours	%Time	Hours	%Time	Hours	%Time
Microenvironment						
Indoors	21.9	91.4%	21.5	89.7%	20.9	87.1%
Outdoors	1.7	7.1%	2.3	9.6%	3.1	12.9%
In-Vehicle	0.3	1.4%	0.2	0.7%	0.0	0.0%
Travel & Mode						
Not Traveling	22.8	95.0%	22.9	95.3%	23.2	96.6%
Walking	0.9	3.6%	0.9	4.0%	0.8	3.4%
Biking	0	0.0%	0.0	0.0%	0.0	0.0%
Transit Travel	0	0.0%	0.0	0.0%	0.0	0.0%
Vehicle Travel	0.3	1.4%	0.2	0.7%	0.0	0.0%
Traffic Level within 200m						
Low	23.6	98.5%	23.9	99.5%	24.0	100.0%
Medium	0.4	1.5%	0.1	0.5%	0.0	0.0%
High	0	0.0%	0.0	0.0%	0.0	0.0%
Truck Route within 200m						
No Nearby Truck Route	24	100.0%	24.0	100.0%	24.0	100.0%
Nearby Truck Route	0	0.0%	0.0	0.0%	0.0	0.0%

Table B. Unique Trips by Destination Type

	Day 1					Day 2					Day 3				
Description	**Total**	**Walking**	**Biking**	**Transit**	**Vehicle**	**Total**	**Walking**	**Biking**	**Transit**	**Vehicle**	**Total**	**Walking**	**Biking**	**Transit**	**Vehicle**
Total	**12**	**9**	**0**	**0**	**3**	**13**	**11**	**0**	**0**	**2**	**11**	**11**	**0**	**0**	**0**
Home	**5**	4	0	0	1	**6**	5	0	0	1	**5**	5	0	0	0
Work	**0**	0	0	0	0	**0**	0	0	0	0	**0**	0	0	0	0
Education	**0**	0	0	0	0	**1**	1	0	0	0	**1**	1	0	0	0
Volunteer	**0**	0	0	0	0	**0**	0	0	0	0	**0**	0	0	0	0
Pickup-Dropoff	**4**	4	0	0	0	**4**	4	0	0	0	**4**	4	0	0	0
Dining/Eating	**0**	0	0	0	0	**0**	0	0	0	0	**0**	0	0	0	0
Shopping/Retail	**1**	0	0	0	1	**1**	0	0	0	1	**0**	0	0	0	0
Services	**1**	0	0	0	1	**0**	0	0	0	0	**0**	0	0	0	0
Recreational/Exercise	**1**	1	0	0	0	**1**	1	0	0	0	**1**	1	0	0	0
Residential Visit	**0**	0	0	0	0	**0**	0	0	0	0	**0**	0	0	0	0
Community/Public	**0**	0	0	0	0	**0**	0	0	0	0	**0**	0	0	0	0

Participant 208:

Profile: Female, Hispanic, between 40-65 years old, prefers Spanish, completed some college

Household Composition: No young children (<5), one older child (6-17), four adults (18-65), no seniors (>65)

Work and Transportation: Works away from and at home, four household cars

Table A. Hours and Percent of Day by Microenvironment, Travel Mode and Proximity to Traffic and Truck Routes

	Day 1		Day 2		Day 3	
	Hours	**%Time**	**Hours**	**%Time**	**Hours**	**%Time**
Microenvironment						
Indoors	17.7	73.9%	20.8	86.6%	20.9	87.3%
Outdoors	3	12.6%	0.8	3.5%	0.2	0.9%
In-Vehicle	3.2	13.4%	2.4	9.9%	2.8	11.8%
Travel & Mode						
Not Traveling	21.4	89.1%	22.3	92.9%	22.6	94.3%
Walking	0.1	0.4%	0.0	0.0%	0.0	0.2%
Biking	0	0.0%	0.0	0.0%	0.0	0.0%
Transit Travel	0	0.0%	0.0	0.0%	0.0	0.0%
Vehicle Travel	2.5	10.5%	1.7	7.1%	1.3	5.5%
Traffic Level within 200m						
Low	2.7	11.2%	3.4	14.0%	1.7	7.2%
Medium	21.1	87.9%	19.7	81.9%	22.0	91.5%
High	0.2	0.9%	1.0	4.1%	0.3	1.3%
Truck Route within 200m						
No Nearby Truck Route	22.9	95.4%	23.1	96.4%	23.9	99.4%
Nearby Truck Route	1.1	4.6%	0.9	3.6%	0.1	0.6%

Table B. Unique Trips by Destination Type

	Day 1					Day 2					Day 3				
Description	**Total**	**Walking**	**Biking**	**Transit**	**Vehicle**	**Total**	**Walking**	**Biking**	**Transit**	**Vehicle**	**Total**	**Walking**	**Biking**	**Transit**	**Vehicle**
Total	**20**	**2**	**0**	**0**	**18**	**12**	**0**	**0**	**0**	**12**	**9**	**1**	**0**	**0**	**8**
Home	**4**	0	0	0	4	**2**	0	0	0	2	**2**	0	0	0	2
Work	**1**	0	0	0	1	**1**	0	0	0	1	**1**	0	0	0	1
Education	**0**	0	0	0	0	**0**	0	0	0	0	**0**	0	0	0	0
Volunteer	**0**	0	0	0	0	**0**	0	0	0	0	**0**	0	0	0	0
Pickup-Dropoff	**3**	0	0	0	3	**4**	0	0	0	4	**1**	0	0	0	1
Dining/Eating	**3**	0	0	0	3	**0**	0	0	0	0	**0**	0	0	0	0
Shopping/Retail	**5**	2	0	0	3	**4**	0	0	0	4	**3**	1	0	0	2
Services	**1**	0	0	0	1	**0**	0	0	0	0	**1**	0	0	0	1
Recreational/Exercise	**0**	0	0	0	0	**0**	0	0	0	0	**0**	0	0	0	0
Residential Visit	**3**	0	0	0	3	**1**	0	0	0	1	**1**	0	0	0	1
Community/Public	**0**	0	0	0	0	**0**	0	0	0	0	**0**	0	0	0	0

Participant 209:

Profile: Female, Hispanic, between 40-65 years old, prefers Spanish, completed high school

Household Composition: No young children (<5), no older children (6-17), three adults (18-65), no seniors (>65)

Work and Transportation: Works away from home fulltime / homemaker, two household cars

Table A. Hours and Percent of Day by Microenvironment, Travel Mode and Proximity to Traffic and Truck Routes

	Day 2		Day 3	
	Hours	**%Time**	**Hours**	**%Time**
Microenvironment				
Indoors	20.0	83.3%	20.6	85.8%
Outdoors	1.9	7.9%	2.7	11.1%
In-Vehicle	2.1	8.8%	0.7	3.1%
Travel & Mode				
Not Traveling	21.9	91.2%	23.3	96.9%
Walking	0.0	0.0%	0.0	0.0%
Biking	0.0	0.0%	0.0	0.0%
Transit Travel	0.0	0.0%	0.0	0.0%
Vehicle Travel	2.1	8.8%	0.7	3.1%
Traffic Level within 200m				
Low	0.6	2.7%	1.9	7.7%
Medium	21.4	89.1%	21.9	91.4%
High	2.0	8.3%	0.2	0.9%
Truck Route within 200m				
No Nearby Truck Route	22.0	91.6%	21.2	88.3%
Nearby Truck Route	2.0	8.4%	2.8	11.7%

Table B. Unique Trips by Destination Type

	Day 2					Day 3				
Description	**Total**	**Walking**	**Biking**	**Transit**	**Vehicle**	**Total**	**Walking**	**Biking**	**Transit**	**Vehicle**
Total	**10**	**0**	**0**	**0**	**10**	**5**	**0**	**0**	**0**	**5**
Home	2	0	0	0	2	**1**	0	0	0	1
Work	0	0	0	0	0	**0**	0	0	0	0
Education	0	0	0	0	0	**0**	0	0	0	0
Volunteer	0	0	0	0	0	**0**	0	0	0	0
Pickup-Dropoff	0	0	0	0	0	**0**	0	0	0	0
Dining/Eating	1	0	0	0	1	**0**	0	0	0	0
Shopping/Retail	3	0	0	0	3	**4**	0	0	0	4
Services	4	0	0	0	4	**0**	0	0	0	0
Recreational/Exercise	0	0	0	0	0	**0**	0	0	0	0
Residential Visit	0	0	0	0	0	**0**	0	0	0	0
Community/Public	0	0	0	0	0	**0**	0	0	0	0

Participant 210:

Profile: Female, Hispanic, between 21-39 years old, prefers Spanish, completed high school

Household Composition: No young children (<5), one older child (6-17), three adults (18-65), no seniors (>65)

Work and Transportation: Student and homemaker, two household cars

Table A. Hours and Percent of Day by Microenvironment, Travel Mode and Proximity to Traffic and Truck Routes

	Day 1		Day 2		Day 3	
	Hours	**%Time**	**Hours**	**%Time**	**Hours**	**%Time**
Microenvironment						
Indoors	20.8	86.7%	20.6	85.8%	23.2	96.5%
Outdoors	1.4	5.7%	0.5	2.2%	0.3	1.3%
In-Vehicle	1.8	7.6%	2.9	12.1%	0.5	2.2%
Travel & Mode						
Not Traveling	22.4	93.4%	21.4	89.3%	23.5	97.9%
Walking	0	0.0%	0.0	0.0%	0.0	0.0%
Biking	0	0.0%	0.0	0.0%	0.0	0.0%
Transit Travel	0	0.0%	0.0	0.0%	0.0	0.0%
Vehicle Travel	1.6	6.6%	2.6	10.7%	0.5	2.1%
Traffic Level within 200m						
Low	8.7	36.4%	6.6	27.6%	3.0	12.3%
Medium	13.8	57.3%	17.2	71.6%	21.0	87.7%
High	1.5	6.3%	0.2	0.8%	0.0	0.0%
Truck Route within 200m						
No Nearby Truck Route	22.3	93.1%	23.7	98.6%	24.0	100.0%
Nearby Truck Route	1.7	6.9%	0.3	1.4%	0.0	0.0%

Table B. Unique Trips by Destination Type

	Day 1					Day 2					Day 3				
Description	**Total**	**Walking**	**Biking**	**Transit**	**Vehicle**	**Total**	**Walking**	**Biking**	**Transit**	**Vehicle**	**Total**	**Walking**	**Biking**	**Transit**	**Vehicle**
Total	**11**	**0**	**0**	**0**	**11**	**13**	**0**	**0**	**0**	**13**	**7**	**0**	**0**	**0**	**7**
Home	**2**	0	0	0	2	**2**	0	0	0	2	**1**	0	0	0	1
Work	**0**	0	0	0	0	**0**	0	0	0	0	**0**	0	0	0	0
Education	**0**	0	0	0	0	**1**	0	0	0	1	**1**	0	0	0	1
Volunteer	**0**	0	0	0	0	**0**	0	0	0	0	**0**	0	0	0	0
Pickup-Dropoff	**3**	0	0	0	3	**2**	0	0	0	2	**1**	0	0	0	1
Dining/Eating	**0**	0	0	0	0	**2**	0	0	0	2	**2**	0	0	0	2
Shopping/Retail	**1**	0	0	0	1	**1**	0	0	0	1	**0**	0	0	0	0
Services	**1**	0	0	0	1	**0**	0	0	0	0	**1**	0	0	0	1
Recreational/Exercise	**0**	0	0	0	0	**0**	0	0	0	0	**0**	0	0	0	0
Residential Visit	**4**	0	0	0	4	**5**	0	0	0	5	**1**	0	0	0	1
Community/Public	**0**	0	0	0	0	**0**	0	0	0	0	**0**	0	0	0	0

Participant 211:

Profile: Female, Hispanic, over 65 years old, prefers Spanish, completed less than high school

Household Composition: No young child (<5), one older child (6-17), three adults (18-65), one seniors (>65)

Work and Transportation: Works away from home / homemaker, one household car

Table A. Hours and Percent of Day by Microenvironment, Travel Mode and Proximity to Traffic and Truck Routes

	Day 1		Day 2		Day 3	
	Hours	**%Time**	**Hours**	**%Time**	**Hours**	**%Time**
Microenvironment						
Indoors	22.4	93.3%	23.3	97.2%	22.2	92.4%
Outdoors	1.5	6.1%	0.4	1.8%	0.7	2.9%
In-Vehicle	0.2	0.7%	0.2	0.9%	1.1	4.7%
Travel & Mode						
Not Traveling	23	96.0%	23.5	98.0%	22.5	93.6%
Walking	0.8	3.3%	0.3	1.0%	0.4	1.7%
Biking	0	0.0%	0.0	0.0%	0.0	0.0%
Transit Travel	0	0.0%	0.0	0.0%	1.1	4.7%
Vehicle Travel	0.2	0.7%	0.2	0.9%	0.0	0.0%
Traffic Level within 200m						
Low	24	100.0%	24.0	99.9%	21.7	90.4%
Medium	0	0.0%	0.0	0.1%	2.3	9.4%
High	0	0.0%	0.0	0.0%	0.0	0.2%
Truck Route within 200m						
No Nearby Truck Route	24	100.0%	24.0	100.0%	24.0	99.8%
Nearby Truck Route	0	0.0%	0.0	0.0%	0.0	0.2%

Table B. Unique Trips by Destination Type

	Day 1					Day 2					Day 3				
Description	**Total**	**Walking**	**Biking**	**Transit**	**Vehicle**	**Total**	**Walking**	**Biking**	**Transit**	**Vehicle**	**Total**	**Walking**	**Biking**	**Transit**	**Vehicle**
Total	**8**	**6**	**0**	**0**	**2**	**5**	**3**	**0**	**0**	**2**	**4**	**2**	**0**	**2**	**0**
Home	**3**	2	0	0	1	**2**	1	0	0	1	**2**	1	0	1	0
Work	**0**	0	0	0	0	**0**	0	0	0	0	**0**	0	0	0	0
Education	**1**	1	0	0	0	**2**	1	0	0	1	**0**	0	0	0	0
Volunteer	**0**	0	0	0	0	**0**	0	0	0	0	**0**	0	0	0	0
Pickup-Dropoff	**0**	0	0	0	0	**0**	0	0	0	0	**0**	0	0	0	0
Dining/Eating	**0**	0	0	0	0	**0**	0	0	0	0	**0**	0	0	0	0
Shopping/Retail	**3**	2	0	0	1	**0**	0	0	0	0	**2**	1	0	1	0
Services	**1**	1	0	0	0	**0**	0	0	0	0	**0**	0	0	0	0
Recreational/Exercise	**0**	0	0	0	0	**1**	1	0	0	0	**0**	0	0	0	0
Residential Visit	**0**	0	0	0	0	**0**	0	0	0	0	**0**	0	0	0	0
Community/Public	**0**	0	0	0	0	**0**	0	0	0	0	**0**	0	0	0	0

Participant 212:

Profile: Female, Hispanic, between 40-65 years old, prefers Spanish, completed less than high school

Household Composition: Two young children (<5), four older children (6-17), four adults (18-65), no seniors (>65)

Work and Transportation: Student / working / homemaker, one household car

Table A. Hours and Percent of Day by Microenvironment, Travel Mode and Proximity to Traffic and Truck Routes

	Day 1		Day 2		Day 3	
	Hours	**%Time**	**Hours**	**%Time**	**Hours**	**%Time**
Microenvironment						
Indoors	22.6	94.0%	24.0	100.0%	23.1	96.4%
Outdoors	0.9	3.6%	0.0	0.0%	0.9	3.6%
In-Vehicle	0.6	2.4%	0.0	0.0%	0.0	0.0%
Travel & Mode						
Not Traveling	22.9	95.3%	24.0	100.0%	23.2	96.6%
Walking	0.5	2.3%	0.0	0.0%	0.8	3.4%
Biking	0	0.0%	0.0	0.0%	0.0	0.0%
Transit Travel	0.6	2.4%	0.0	0.0%	0.0	0.0%
Vehicle Travel	0	0.0%	0.0	0.0%	0.0	0.0%
Traffic Level within 200m						
Low	23.7	98.7%	24.0	100.0%	24.0	100.0%
Medium	0.3	1.3%	0.0	0.0%	0.0	0.0%
High	0	0.0%	0.0	0.0%	0.0	0.0%
Truck Route within 200m						
No Nearby Truck Route	23.9	99.4%	24.0	100.0%	24.0	100.0%
Nearby Truck Route	0.1	0.6%	0.0	0.0%	0.0	0.0%

Table B. Unique Trips by Destination Type

	Day 1					Day 2					Day 3				
Description	**Total**	**Walking**	**Biking**	**Transit**	**Vehicle**	**Total**	**Walking**	**Biking**	**Transit**	**Vehicle**	**Total**	**Walking**	**Biking**	**Transit**	**Vehicle**
Total	**9**	**7**	**0**	**2**	**0**	**0**	**0**	**0**	**0**	**0**	**4**	**4**	**0**	**0**	**0**
Home	**4**	3	0	1	0	**0**	0	0	0	0	**2**	2	0	0	0
Work	**0**	0	0	0	0	**0**	0	0	0	0	**0**	0	0	0	0
Education	**3**	2	0	1	0	**0**	0	0	0	0	**0**	0	0	0	0
Volunteer	**0**	0	0	0	0	**0**	0	0	0	0	**0**	0	0	0	0
Pickup-Dropoff	**1**	1	0	0	0	**0**	0	0	0	0	**2**	2	0	0	0
Dining/Eating	**0**	0	0	0	0	**0**	0	0	0	0	**0**	0	0	0	0
Shopping/Retail	**1**	1	0	0	0	**0**	0	0	0	0	**0**	0	0	0	0
Services	**0**	0	0	0	0	**0**	0	0	0	0	**0**	0	0	0	0
Recreational/Exercise	**0**	0	0	0	0	**0**	0	0	0	0	**0**	0	0	0	0
Residential Visit	**0**	0	0	0	0	**0**	0	0	0	0	**0**	0	0	0	0
Community/Public	**0**	0	0	0	0	**0**	0	0	0	0	**0**	0	0	0	0

Participant 213:

Profile: Female, Hispanic, between 40-65 years old, prefers Spanish, completed high school

Household Composition: No young children (<5), one older child (6-17), four adults (18-65), no seniors (>65)

Work and Transportation: Works away from home fulltime, one household cars

Table A. Hours and Percent of Day by Microenvironment, Travel Mode and Proximity to Traffic and Truck Routes

	Day 1		Day 2		Day 3	
	Hours	%Time	Hours	%Time	Hours	%Time
Microenvironment						
Indoors	23.7	98.6%	23.7	98.7%	24.0	100.0%
Outdoors	0.2	0.6%	0.1	0.3%	0.0	0.0%
In-Vehicle	0.2	0.7%	0.2	0.9%	0.0	0.0%
Travel & Mode						
Not Traveling	23.7	98.9%	23.7	98.9%	24.0	100.0%
Walking	0.1	0.4%	0.0	0.2%	0.0	0.0%
Biking	0	0.0%	0.0	0.0%	0.0	0.0%
Transit Travel	0	0.0%	0.0	0.0%	0.0	0.0%
Vehicle Travel	0.2	0.7%	0.2	0.9%	0.0	0.0%
Traffic Level within 200m						
Low	15.3	63.7%	15.2	63.5%	24.0	100.0%
Medium	8.7	36.3%	8.8	36.5%	0.0	0.0%
High	0	0.1%	0.0	0.1%	0.0	0.0%
Truck Route within 200m						
No Nearby Truck Route	15.1	63.0%	15.1	63.1%	24.0	100.0%
Nearby Truck Route	8.9	37.0%	8.9	36.9%	0.0	0.0%

Table B. Unique Trips by Destination Type

	Day 1					Day 2					Day 3				
Description	**Total**	**Walking**	**Biking**	**Transit**	**Vehicle**	**Total**	**Walking**	**Biking**	**Transit**	**Vehicle**	**Total**	**Walking**	**Biking**	**Transit**	**Vehicle**
Total	**3**	**1**	**0**	**0**	**2**	**3**	**1**	**0**	**0**	**2**	**0**	**0**	**0**	**0**	**0**
Home	**2**	1	0	0	1	**1**	0	0	0	1	**0**	0	0	0	0
Work	**1**	0	0	0	1	**1**	0	0	0	1	**0**	0	0	0	0
Education	**0**	0	0	0	0	**0**	0	0	0	0	**0**	0	0	0	0
Volunteer	**0**	0	0	0	0	**0**	0	0	0	0	**0**	0	0	0	0
Pickup-Dropoff	**0**	0	0	0	0	**0**	0	0	0	0	**0**	0	0	0	0
Dining/Eating	**0**	0	0	0	0	**0**	0	0	0	0	**0**	0	0	0	0
Shopping/Retail	**0**	0	0	0	0	**0**	0	0	0	0	**0**	0	0	0	0
Services	**0**	0	0	0	0	**0**	0	0	0	0	**0**	0	0	0	0
Recreational/Exercise	**0**	0	0	0	0	**0**	0	0	0	0	**0**	0	0	0	0
Residential Visit	**0**	0	0	0	0	**1**	1	0	0	0	**0**	0	0	0	0
Community/Public	**0**	0	0	0	0	**0**	0	0	0	0	**0**	0	0	0	0

Participant 214:

Profile: Female, Hispanic, over 65 years old, prefers English, completed some college
Household Composition: No young children (<5), one older child (6-17), two adults (18-65), no seniors (>65)
Work and Transportation: Works away from home part time, no household car

Table A. Hours and Percent of Day by Microenvironment, Travel Mode and Proximity to Traffic and Truck Routes

	Day 1		Day 2	
	Hours	**%Time**	**Hours**	**%Time**
Microenvironment				
Indoors	21.9	91.1%	21.4	89.2%
Outdoors	1.4	5.9%	1.5	6.3%
In-Vehicle	0.7	3.1%	1.1	4.5%
Travel & Mode				
Not Traveling	22.2	92.6%	22.3	92.9%
Walking	1	4.3%	0.6	2.5%
Biking	0	0.0%	0.0	0.0%
Transit Travel	0.7	3.1%	0.9	3.8%
Vehicle Travel	0	0.0%	0.2	0.8%
Traffic Level within 200m				
Low	23	95.7%	22.3	93.0%
Medium	0.8	3.4%	1.4	5.9%
High	0.2	0.9%	0.3	1.1%
Truck Route within 200m				
No Nearby Truck Route	23.5	97.8%	22.4	93.5%
Nearby Truck Route	0.5	2.2%	1.6	6.5%

Table B. Unique Trips by Destination Type

	Day 1					Day 2				
Description	**Total**	**Walking**	**Biking**	**Transit**	**Vehicle**	**Total**	**Walking**	**Biking**	**Transit**	**Vehicle**
Total	**7**	**5**	**0**	**2**	**0**	**9**	**4**	**0**	**3**	**2**
Home	**1**	1	0	0	0	**1**	1	0	0	0
Work	**3**	2	0	1	0	**3**	1	0	1	1
Education	**0**	0	0	0	0	**0**	0	0	0	0
Volunteer	**0**	0	0	0	0	**0**	0	0	0	0
Pickup-Dropoff	**0**	0	0	0	0	**0**	0	0	0	0
Dining/Eating	**0**	0	0	0	0	**1**	0	0	0	1
Shopping/Retail	**0**	0	0	0	0	**0**	0	0	0	0
Services	**0**	0	0	0	0	**0**	0	0	0	0
Recreational/Exercise	**0**	0	0	0	0	**0**	0	0	0	0
Residential Visit	**3**	2	0	1	0	**4**	2	0	2	0
Community/Public	**0**	0	0	0	0	**0**	0	0	0	0

Participant 215:

Profile: Male, Non-Hispanic, between 40-65 years old, prefers English, completed some college

Household Composition: No young children (<5), no older children (6-17), two adults (18-65), no seniors (>65)

Work and Transportation: Looking for work, no household car

Table A. Hours and Percent of Day by Microenvironment, Travel Mode and Proximity to Traffic and Truck Routes

	Day 1		Day 2		Day 3	
	Hours	**%Time**	**Hours**	**%Time**	**Hours**	**%Time**
Microenvironment						
Indoors	22.4	93.2%	20.9	87.3%	22.5	93.6%
Outdoors	0.3	1.1%	0.7	2.9%	0.3	1.3%
In-Vehicle	1.4	5.7%	2.4	9.8%	1.2	5.2%
Travel & Mode						
Not Traveling	22.8	95.0%	21.8	90.8%	22.8	94.9%
Walking	0	0.0%	0.0	0.0%	0.0	0.0%
Biking	0	0.0%	0.0	0.0%	0.0	0.0%
Transit Travel	0	0.0%	0.0	0.0%	0.0	0.0%
Vehicle Travel	1.2	5.0%	2.2	9.2%	1.2	5.1%
Traffic Level within 200m						
Low	23.2	96.6%	22.4	93.2%	22.5	93.6%
Medium	0.4	1.7%	0.8	3.3%	1.1	4.5%
High	0.4	1.7%	0.8	3.5%	0.5	1.9%
Truck Route within 200m						
No Nearby Truck Route	23.7	98.8%	23.2	96.8%	23.7	98.6%
Nearby Truck Route	0.3	1.2%	0.8	3.2%	0.3	1.4%

Table B. Unique Trips by Destination Type

	Day 1					Day 2					Day 3				
Description	**Total**	**Walking**	**Biking**	**Transit**	**Vehicle**	**Total**	**Walking**	**Biking**	**Transit**	**Vehicle**	**Total**	**Walking**	**Biking**	**Transit**	**Vehicle**
Total	**5**	**0**	**0**	**0**	**5**	**11**	**0**	**0**	**0**	**11**	**7**	**0**	**0**	**0**	**7**
Home	**2**	0	0	0	2	**3**	0	0	0	3	**3**	0	0	0	3
Work	**0**	0	0	0	0	**0**	0	0	0	0	**0**	0	0	0	0
Education	**0**	0	0	0	0	**0**	0	0	0	0	**0**	0	0	0	0
Volunteer	**0**	0	0	0	0	**0**	0	0	0	0	**1**	0	0	0	1
Pickup-Dropoff	**2**	0	0	0	2	**2**	0	0	0	2	**2**	0	0	0	2
Dining/Eating	**0**	0	0	0	0	**0**	0	0	0	0	**0**	0	0	0	0
Shopping/Retail	**0**	0	0	0	0	**2**	0	0	0	2	**1**	0	0	0	1
Services	**1**	0	0	0	1	**4**	0	0	0	4	**0**	0	0	0	0
Recreational/Exercise	**0**	0	0	0	0	**0**	0	0	0	0	**0**	0	0	0	0
Residential Visit	**0**	0	0	0	0	**0**	0	0	0	0	**0**	0	0	0	0
Community/Public	**0**	0	0	0	0	**0**	0	0	0	0	**0**	0	0	0	0

Participant 216:

Profile: Female, Hispanic, between 21-39 years old, prefers Spanish, completed some college

Household Composition: One young child (<5), one older child (6-17), two adults (18-65), no seniors (>65)

Work and Transportation: Student without working, two household cars

Table A. Hours and Percent of Day by Microenvironment, Travel Mode and Proximity to Traffic and Truck Routes

	Day 1		Day 2		Day 3	
	Hours	**%Time**	**Hours**	**%Time**	**Hours**	**%Time**
Microenvironment						
Indoors	21.8	90.8%	18.1	75.3%	20.5	85.6%
Outdoors	0.7	2.9%	4.4	18.3%	2.1	8.6%
In-Vehicle	1.5	6.3%	1.5	6.4%	1.4	5.8%
Travel & Mode						
Not Traveling	22.8	94.9%	22.5	93.9%	22.4	93.2%
Walking	0	0.0%	0.3	1.4%	0.4	1.6%
Biking	0	0.0%	0.0	0.0%	0.0	0.0%
Transit Travel	0	0.0%	0.0	0.0%	0.0	0.0%
Vehicle Travel	1.2	5.1%	1.1	4.8%	1.3	5.2%
Traffic Level within 200m						
Low	20.1	83.9%	23.5	98.0%	23.0	95.7%
Medium	0.3	1.3%	0.4	1.7%	0.8	3.3%
High	3.6	14.8%	0.1	0.3%	0.2	1.0%
Truck Route within 200m						
No Nearby Truck Route	19.2	80.1%	23.8	99.1%	23.4	97.7%
Nearby Truck Route	4.8	19.9%	0.2	0.9%	0.6	2.3%

Table B. Unique Trips by Destination Type

	Day 1					Day 2					Day 3				
Description	**Total**	**Walking**	**Biking**	**Transit**	**Vehicle**	**Total**	**Walking**	**Biking**	**Transit**	**Vehicle**	**Total**	**Walking**	**Biking**	**Transit**	**Vehicle**
Total	**8**	**0**	**0**	**0**	**8**	**10**	**2**	**0**	**0**	**8**	**9**	**2**	**0**	**0**	**7**
Home	**3**	0	0	0	3	**3**	1	0	0	2	**3**	1	0	0	2
Work	**0**	0	0	0	0	**0**	0	0	0	0	**0**	0	0	0	0
Education	**0**	0	0	0	0	**0**	0	0	0	0	**1**	0	0	0	1
Volunteer	**0**	0	0	0	0	**0**	0	0	0	0	**0**	0	0	0	0
Pickup-Dropoff	**2**	0	0	0	2	**1**	0	0	0	1	**1**	0	0	0	1
Dining/Eating	**0**	0	0	0	0	**0**	0	0	0	0	**0**	0	0	0	0
Shopping/Retail	**2**	0	0	0	2	**3**	1	0	0	2	**2**	0	0	0	2
Services	**0**	0	0	0	0	**0**	0	0	0	0	**0**	0	0	0	0
Recreational/Exercise	**0**	0	0	0	0	**1**	0	0	0	1	**1**	1	0	0	0
Residential Visit	**1**	0	0	0	1	**2**	0	0	0	2	**1**	0	0	0	1
Community/Public	**0**	0	0	0	0	**0**	0	0	0	0	**0**	0	0	0	0

Participant 217:

Profile: Female, Hispanic, between 40-65 years old, prefers Spanish, completed less than high school

Household Composition: No young children (<5), one older child (6-17), two adults (18-65), no seniors (>65)

Work and Transportation: Volunteer / homemaker / student, one household cars

Table A. Hours and Percent of Day by Microenvironment, Travel Mode and Proximity to Traffic and Truck Routes

	Day 1		Day 2		Day 3	
	Hours	%Time	Hours	%Time	Hours	%Time
Microenvironment						
Indoors	22.8	95.0%	24.0	100.0%	23.6	98.4%
Outdoors	0.3	1.1%	0.0	0.0%	0.3	1.3%
In-Vehicle	0.9	3.9%	0.0	0.0%	0.1	0.3%
Travel & Mode						
Not Traveling	23.1	96.3%	24.0	100.0%	23.8	99.0%
Walking	0	0.0%	0.0	0.0%	0.2	0.7%
Biking	0	0.0%	0.0	0.0%	0.0	0.0%
Transit Travel	0	0.0%	0.0	0.0%	0.0	0.0%
Vehicle Travel	0.9	3.6%	0.0	0.0%	0.1	0.3%
Traffic Level within 200m						
Low	20.8	86.6%	24.0	100.0%	23.8	99.0%
Medium	3.2	13.4%	0.0	0.0%	0.2	1.0%
High	0	0.0%	0.0	0.0%	0.0	0.0%
Truck Route within 200m						
No Nearby Truck Route	23.9	99.5%	24.0	100.0%	24.0	100.0%
Nearby Truck Route	0.1	0.5%	0.0	0.0%	0.0	0.0%

Table B. Unique Trips by Destination Type

	Day 1					Day 2					Day 3				
Description	**Total**	**Walking**	**Biking**	**Transit**	**Vehicle**	**Total**	**Walking**	**Biking**	**Transit**	**Vehicle**	**Total**	**Walking**	**Biking**	**Transit**	**Vehicle**
Total	**7**	**0**	**0**	**0**	**7**	**0**	**0**	**0**	**0**	**0**	**4**	**2**	**0**	**0**	**2**
Home	**2**	0	0	0	2	**0**	0	0	0	0	**2**	1	0	0	1
Work	**0**	0	0	0	0	**0**	0	0	0	0	**0**	0	0	0	0
Education	**0**	0	0	0	0	**0**	0	0	0	0	**2**	1	0	0	1
Volunteer	**0**	0	0	0	0	**0**	0	0	0	0	**0**	0	0	0	0
Pickup-Dropoff	**1**	0	0	0	1	**0**	0	0	0	0	**0**	0	0	0	0
Dining/Eating	**0**	0	0	0	0	**0**	0	0	0	0	**0**	0	0	0	0
Shopping/Retail	**3**	0	0	0	3	**0**	0	0	0	0	**0**	0	0	0	0
Services	**1**	0	0	0	1	**0**	0	0	0	0	**0**	0	0	0	0
Recreational/Exercise	**0**	0	0	0	0	**0**	0	0	0	0	**0**	0	0	0	0
Residential Visit	**0**	0	0	0	0	**0**	0	0	0	0	**0**	0	0	0	0
Community/Public	**0**	0	0	0	0	**0**	0	0	0	0	**0**	0	0	0	0

Participant 218:

Profile: Female, Hispanic, between 21-39 years old, prefers English, completed high school

Household Composition: No young child (<5), four older children (6-17), one adults (18-65), no seniors (>65)

Work and Transportation: Works at home and office, two household cars

Table A. Hours and Percent of Day by Microenvironment, Travel Mode and Proximity to Traffic and Truck Routes

	Day 1		Day 3	
	Hours	%Time	Hours	%Time
Microenvironment				
Indoors	18.8	78.2%	17.0	70.7%
Outdoors	1.3	5.3%	0.5	2.1%
In-Vehicle	4	16.5%	6.5	27.2%
Travel & Mode				
Not Traveling	21.3	88.7%	22.6	94.2%
Walking	0	0.0%	0.0	0.0%
Biking	0	0.0%	0.0	0.0%
Transit Travel	0	0.0%	0.0	0.0%
Vehicle Travel	2.7	11.3%	1.4	5.8%
Traffic Level within 200m				
Low	21.5	89.7%	21.9	91.2%
Medium	2.5	10.3%	2.1	8.8%
High	0	0.0%	0.0	0.0%
Truck Route within 200m				
No Nearby Truck Route	23.6	98.2%	23.7	98.7%
Nearby Truck Route	0.4	1.8%	0.3	1.3%

Table B. Unique Trips by Destination Type

	Day 1					Day 3				
Description	**Total**	**Walking**	**Biking**	**Transit**	**Vehicle**	**Total**	**Walking**	**Biking**	**Transit**	**Vehicle**
Total	**15**	**0**	**0**	**0**	**15**	**10**	**0**	**0**	**0**	**10**
Home	**3**	0	0	0	3	**3**	0	0	0	3
Work	**0**	0	0	0	0	**0**	0	0	0	0
Education	**2**	0	0	0	2	**0**	0	0	0	0
Volunteer	**0**	0	0	0	0	**0**	0	0	0	0
Pickup-Dropoff	**7**	0	0	0	7	**3**	0	0	0	3
Dining/Eating	**1**	0	0	0	1	**0**	0	0	0	0
Shopping	**0**	0	0	0	0	**2**	0	0	0	2
Services	**1**	0	0	0	1	**1**	0	0	0	1
Recreational/Exercise	**0**	0	0	0	0	**0**	0	0	0	0
Residential Visit	**1**	0	0	0	1	**1**	0	0	0	1
Community/Public	**0**	0	0	0	0	**0**	0	0	0	0

Participant 219:

Profile: Female, Non-Hispanic, between 21-39 years old, prefers English, completed B.A. or higher

Household Composition: No young children (<5), no older children (6-17), two adults (18-65), no seniors (>65)

Work and Transportation: Student and working, two household cars

Table A. Hours and Percent of Day by Microenvironment, Travel Mode and Proximity to Traffic and Truck Routes

	Day 1		Day 2	
	Hours	%Time	Hours	%Time
Microenvironment				
Indoors	21.2	88.2%	18.6	77.3%
Outdoors	0.3	1.4%	0.7	2.8%
In-Vehicle	2.5	10.4%	4.8	19.9%
Travel & Mode				
Not Traveling	21.6	89.8%	19.2	80.1%
Walking	0	0.0%	0.0	0.0%
Biking	0	0.0%	0.0	0.0%
Transit Travel	0	0.0%	0.0	0.0%
Vehicle Travel	2.4	10.2%	4.8	19.9%
Traffic Level within 200m				
Low	10.2	42.6%	9.4	39.1%
Medium	13.5	56.2%	11.2	46.5%
High	0.3	1.1%	3.4	14.4%
Truck Route within 200m				
No Nearby Truck Route	23.7	98.9%	23.7	98.7%
Nearby Truck Route	0.3	1.1%	0.3	1.3%

Table B. Unique Trips by Destination Type

	Day 1					Day 2				
Description	**Total**	**Walking**	**Biking**	**Transit**	**Vehicle**	**Total**	**Walking**	**Biking**	**Transit**	**Vehicle**
Total	**6**	**0**	**0**	**0**	**6**	**13**	**0**	**0**	**0**	**13**
Home	**2**	0	0	0	2	**1**	0	0	0	1
Work	**2**	0	0	0	2	**2**	0	0	0	2
Education	**0**	0	0	0	0	**0**	0	0	0	0
Volunteer	**0**	0	0	0	0	**0**	0	0	0	0
Pickup-Dropoff	**0**	0	0	0	0	**0**	0	0	0	0
Dining/Eating	**2**	0	0	0	2	**3**	0	0	0	3
Shopping/Retail	**0**	0	0	0	0	**2**	0	0	0	2
Services	**0**	0	0	0	0	**1**	0	0	0	1
Recreational/Exercise	**0**	0	0	0	0	**0**	0	0	0	0
Residential Visit	**0**	0	0	0	0	**4**	0	0	0	4
Community/Public	**0**	0	0	0	0	**0**	0	0	0	0

Participant 220:

Profile: Female, Hispanic, between 21-39 years old, prefers English, completed some college

Household Composition: No young children (<5), no older children (6-17), two adults (18-65), no seniors (>65)

Work and Transportation: Student without working, two household cars

Table A. Hours and Percent of Day by Microenvironment, Travel Mode and Proximity to Traffic and Truck Routes

	Day 1		Day 2		Day 3	
	Hours	**%Time**	**Hours**	**%Time**	**Hours**	**%Time**
Microenvironment						
Indoors	22.6	94.3%	19.3	80.4%	22.2	92.4%
Outdoors	0.8	3.3%	3.5	14.6%	0.8	3.3%
In-Vehicle	0.6	2.4%	1.2	5.0%	1.0	4.3%
Travel & Mode						
Not Traveling	23.3	97.0%	23.2	96.5%	23.1	96.4%
Walking	0.1	0.5%	0.0	0.0%	0.0	0.0%
Biking	0	0.0%	0.0	0.0%	0.0	0.0%
Transit Travel	0	0.0%	0.0	0.0%	0.0	0.0%
Vehicle Travel	0.6	2.4%	0.8	3.5%	0.9	3.6%
Traffic Level within 200m						
Low	22.2	92.5%	15.0	62.5%	17.2	71.5%
Medium	1.8	7.5%	9.0	37.5%	6.8	28.5%
High	0	0.0%	0.0	0.0%	0.0	0.0%
Truck Route within 200m						
No Nearby Truck Route	24	100.0%	24.0	100.0%	24.0	100.0%
Nearby Truck Route	0	0.0%	0.0	0.0%	0.0	0.0%

Table B. Unique Trips by Destination Type

	Day 1					Day 2					Day 3				
Description	**Total**	**Walking**	**Biking**	**Transit**	**Vehicle**	**Total**	**Walking**	**Biking**	**Transit**	**Vehicle**	**Total**	**Walking**	**Biking**	**Transit**	**Vehicle**
Total	**9**	**4**	**0**	**0**	**5**	**8**	**0**	**0**	**0**	**8**	**6**	**0**	**0**	**0**	**6**
Home	**4**	2	0	0	2	**3**	0	0	0	3	**2**	0	0	0	2
Work	**0**	0	0	0	0	**0**	0	0	0	0	**0**	0	0	0	0
Education	**0**	0	0	0	0	**3**	0	0	0	3	**3**	0	0	0	3
Volunteer	**0**	0	0	0	0	**0**	0	0	0	0	**0**	0	0	0	0
Pickup-Dropoff	**0**	0	0	0	0	**1**	0	0	0	1	**0**	0	0	0	0
Dining/Eating	**0**	0	0	0	0	**0**	0	0	0	0	**0**	0	0	0	0
Shopping/Retail	**5**	2	0	0	3	**1**	0	0	0	1	**0**	0	0	0	0
Services	**0**	0	0	0	0	**0**	0	0	0	0	**0**	0	0	0	0
Recreational/Exercise	**0**	0	0	0	0	**0**	0	0	0	0	**0**	0	0	0	0
Residential Visit	**0**	0	0	0	0	**0**	0	0	0	0	**1**	0	0	0	1
Community/Public	**0**	0	0	0	0	**0**	0	0	0	0	**0**	0	0	0	0

Participant 221:

Profile: Female, Hispanic, between 21-39 years old, prefers Spanish, completed less than high school

Household Composition: One young child (<5), one older children (6-17), three adults (18-65), no seniors (>65)

Work and Transportation: Works at home / homemaker, one household car

Table A. Hours and Percent of Day by Microenvironment, Travel Mode and Proximity to Traffic and Truck Routes

	Day 1		Day 2		Day 3	
	Hours	**%Time**	**Hours**	**%Time**	**Hours**	**%Time**
Microenvironment						
Indoors	23.1	96.3%	22.7	94.7%	23.7	98.6%
Outdoors	0.7	2.9%	0.5	2.2%	0.1	0.6%
In-Vehicle	0.2	0.8%	0.7	3.1%	0.2	0.8%
Travel & Mode						
Not Traveling	23.6	98.4%	23.5	97.7%	23.8	99.2%
Walking	0.2	1.0%	0.1	0.2%	0.0	0.0%
Biking	0	0.0%	0.0	0.0%	0.0	0.0%
Transit Travel	0	0.0%	0.0	0.0%	0.0	0.0%
Vehicle Travel	0.2	0.7%	0.5	2.0%	0.2	0.8%
Traffic Level within 200m						
Low	24	100.0%	24.0	100.0%	24.0	100.0%
Medium	0	0.0%	0.0	0.0%	0.0	0.0%
High	0	0.0%	0.0	0.0%	0.0	0.0%
Truck Route within 200m						
No Nearby Truck Route	24	100.0%	23.6	98.3%	24.0	100.0%
Nearby Truck Route	0	0.0%	0.4	1.7%	0.0	0.0%

Table B. Unique Trips by Destination Type

	Day 1					Day 2					Day 3				
Description	**Total**	**Walking**	**Biking**	**Transit**	**Vehicle**	**Total**	**Walking**	**Biking**	**Transit**	**Vehicle**	**Total**	**Walking**	**Biking**	**Transit**	**Vehicle**
Total	**4**	**2**	**0**	**0**	**2**	**6**	**1**	**0**	**0**	**5**	**1**	**0**	**0**	**0**	**1**
Home	**0**	0	0	0	0	**1**	0	0	0	1	**0**	0	0	0	0
Work	**2**	1	0	0	1	**3**	1	0	0	2	**1**	0	0	0	1
Education	**0**	0	0	0	0	**0**	0	0	0	0	**0**	0	0	0	0
Volunteer	**1**	0	0	0	1	**0**	0	0	0	0	**0**	0	0	0	0
Pickup-Dropoff	**1**	1	0	0	0	**0**	0	0	0	0	**0**	0	0	0	0
Dining/Eating	**0**	0	0	0	0	**0**	0	0	0	0	**0**	0	0	0	0
Shopping	**0**	0	0	0	0	**0**	0	0	0	0	**0**	0	0	0	0
Services	**0**	0	0	0	0	**2**	0	0	0	2	**0**	0	0	0	0
Recreational/Exercise	**0**	0	0	0	0	**0**	0	0	0	0	**0**	0	0	0	0
Residential Visit	**0**	0	0	0	0	**0**	0	0	0	0	**0**	0	0	0	0
Community/Public	**0**	0	0	0	0	**0**	0	0	0	0	**0**	0	0	0	0

Participant 223:

Profile: Female, Hispanic, between 40-65 years old, prefers Spanish, completed some college

Household Composition: No young children (<5), four older children (6-17), two adults (18-65), no seniors (>65)

Work and Transportation: Student / homemaker, one household car

Table A. Hours and Percent of Day by Microenvironment, Travel Mode and Proximity to Traffic and Truck Routes

	Day 1		Day 2		Day 3	
	Hours	%Time	Hours	%Time	Hours	%Time
Microenvironment						
Indoors	24	100.0%	21.0	87.4%	22.3	92.7%
Outdoors	0	0.0%	2.5	10.3%	1.1	4.7%
In-Vehicle	0	0.0%	0.6	2.3%	0.6	2.5%
Travel & Mode						
Not Traveling	24	100.0%	21.8	90.8%	22.8	95.1%
Walking	0	0.0%	1.7	7.2%	0.6	2.3%
Biking	0	0.0%	0.0	0.0%	0.0	0.0%
Transit Travel	0	0.0%	0.0	0.0%	0.0	0.0%
Vehicle Travel	0	0.0%	0.5	2.0%	0.6	2.5%
Traffic Level within 200m						
Low	24	100.0%	21.7	90.4%	19.9	83.1%
Medium	0	0.0%	2.3	9.6%	4.0	16.9%
High	0	0.0%	0.0	0.0%	0.0	0.0%
Truck Route within 200m						
No Nearby Truck Route	0	0.0%	5.3	22.2%	0.6	2.5%
Nearby Truck Route	24	100.0%	18.7	77.8%	23.4	97.5%

Table B. Unique Trips by Destination Type

	Day 1					Day 2					Day 3				
Description	**Total**	**Walking**	**Biking**	**Transit**	**Vehicle**	**Total**	**Walking**	**Biking**	**Transit**	**Vehicle**	**Total**	**Walking**	**Biking**	**Transit**	**Vehicle**
Total	**0**	**0**	**0**	**0**	**0**	**12**	**7**	**0**	**0**	**5**	**8**	**3**	**0**	**0**	**5**
Home	**0**	0	0	0	0	**3**	2	0	0	1	**3**	1	0	0	2
Work	**0**	0	0	0	0	**0**	0	0	0	0	**0**	0	0	0	0
Education	**0**	0	0	0	0	**3**	2	0	0	1	**0**	0	0	0	0
Volunteer	**0**	0	0	0	0	**0**	0	0	0	0	**0**	0	0	0	0
Pickup-Dropoff	**0**	0	0	0	0	**1**	0	0	0	1	**0**	0	0	0	0
Dining/Eating	**0**	0	0	0	0	**0**	0	0	0	0	**0**	0	0	0	0
Shopping	**0**	0	0	0	0	**2**	1	0	0	1	**2**	1	0	0	1
Services	**0**	0	0	0	0	**2**	2	0	0	0	**3**	1	0	0	2
Recreational/Exercise	**0**	0	0	0	0	**0**	0	0	0	0	**0**	0	0	0	0
Residential Visit	**0**	0	0	0	0	**1**	0	0	0	1	**0**	0	0	0	0
Community/Public	**0**	0	0	0	0	**0**	0	0	0	0	**0**	0	0	0	0

Participant 224:

Profile: Female, Hispanic, between 21-39 years old, prefers English, completed B.A. or higher

Household Composition: No young children (<5), no older children (6-17), three adults (18-65), no seniors (>65)

Work and Transportation: Works away from home full time, seven household cars

Table A. Hours and Percent of Day by Microenvironment, Travel Mode and Proximity to Traffic and Truck Routes

	Day 2		Day 3	
	Hours	%Time	Hours	%Time
Microenvironment				
Indoors	22.6	94.1%	21.2	88.5%
Outdoors	0.5	2.0%	0.2	0.7%
In-Vehicle	0.9	3.9%	2.6	10.9%
Travel & Mode				
Not Traveling	22.8	94.8%	21.6	89.9%
Walking	0.3	1.4%	0.0	0.0%
Biking	0.0	0.0%	0.0	0.0%
Transit Travel	0.0	0.0%	0.0	0.0%
Vehicle Travel	0.9	3.8%	2.4	10.1%
Traffic Level within 200m				
Low	0.8	3.5%	3.8	15.9%
Medium	22.5	93.8%	20.0	83.4%
High	0.7	2.7%	0.2	0.8%
Truck Route within 200m				
No Nearby Truck Route	23.3	97.2%	23.8	99.4%
Nearby Truck Route	0.7	2.8%	0.2	0.6%

Table B. Unique Trips by Destination Type

	Day 2					Day 3				
Description	**Total**	**Walking**	**Biking**	**Transit**	**Vehicle**	**Total**	**Walking**	**Biking**	**Transit**	**Vehicle**
Total	**8**	**2**	**0**	**0**	**6**	**4**	**0**	**0**	**0**	**4**
Home	**2**	0	0	0	2	**2**	0	0	0	2
Work	**2**	1	0	0	1	**1**	0	0	0	1
Education	**0**	0	0	0	0	**0**	0	0	0	0
Volunteer	**0**	0	0	0	0	**0**	0	0	0	0
Pickup-Dropoff	**0**	0	0	0	0	**0**	0	0	0	0
Dining/Eating	**1**	0	0	0	1	**0**	0	0	0	0
Shopping	**3**	1	0	0	2	**0**	0	0	0	0
Services	**0**	0	0	0	0	**0**	0	0	0	0
Recreational/Exercise	**0**	0	0	0	0	**0**	0	0	0	0
Residential Visit	**0**	0	0	0	0	**1**	0	0	0	1
Community/Public	**0**	0	0	0	0	**0**	0	0	0	0

Participant 225:

Profile: Female, Hispanic, between 40-65 years old, prefers Spanish, completed less than high school

Household Composition: No young children (<5), two older children (6-17), three adults (18-65), no seniors (>65)

Work and Transportation: Works at home / homemaker, one household car

Table A. Hours and Percent of Day by Microenvironment, Travel Mode and Proximity to Traffic and Truck Routes

	Day 1		Day 2		Day 3	
	Hours	%Time	Hours	%Time	Hours	%Time
Microenvironment						
Indoors	20.6	85.8%	23.1	96.3%	23.1	96.1%
Outdoors	1.8	7.6%	0.9	3.7%	0.9	3.9%
In-Vehicle	1.6	6.6%	0.0	0.0%	0.0	0.0%
Travel & Mode						
Not Traveling	20.9	87.2%	23.2	96.8%	23.1	96.4%
Walking	1.7	7.1%	0.8	3.2%	0.9	3.6%
Biking	0	0.0%	0.0	0.0%	0.0	0.0%
Transit Travel	0	0.0%	0.0	0.0%	0.0	0.0%
Vehicle Travel	1.4	5.7%	0.0	0.0%	0.0	0.0%
Traffic Level within 200m						
Low	23.3	97.0%	24.0	100.0%	24.0	100.0%
Medium	0.7	3.0%	0.0	0.0%	0.0	0.0%
High	0	0.0%	0.0	0.0%	0.0	0.0%
Truck Route within 200m						
No Nearby Truck Route	23.7	98.9%	24.0	100.0%	24.0	100.0%
Nearby Truck Route	0.3	1.1%	0.0	0.0%	0.0	0.0%

Table B. Unique Trips by Destination Type

	Day 1					Day 2					Day 3				
Description	**Total**	**Walking**	**Biking**	**Transit**	**Vehicle**	**Total**	**Walking**	**Biking**	**Transit**	**Vehicle**	**Total**	**Walking**	**Biking**	**Transit**	**Vehicle**
Total	**12**	**6**	**0**	**0**	**6**	**6**	**6**	**0**	**0**	**0**	**5**	**5**	**0**	**0**	**0**
Home	**5**	3	0	0	2	**2**	2	0	0	0	**2**	2	0	0	0
Work	**0**	0	0	0	0	**0**	0	0	0	0	**0**	0	0	0	0
Education	**1**	1	0	0	0	**1**	1	0	0	0	**1**	1	0	0	0
Volunteer	**0**	0	0	0	0	**0**	0	0	0	0	**0**	0	0	0	0
Pickup-Dropoff	**1**	1	0	0	0	**1**	1	0	0	0	**1**	1	0	0	0
Dining/Eating	**0**	0	0	0	0	**0**	0	0	0	0	**0**	0	0	0	0
Shopping	**2**	0	0	0	2	**1**	1	0	0	0	**1**	1	0	0	0
Services	**3**	1	0	0	2	**1**	1	0	0	0	**0**	0	0	0	0
Recreational/Exercise	**0**	0	0	0	0	**0**	0	0	0	0	**0**	0	0	0	0
Residential Visit	**0**	0	0	0	0	**0**	0	0	0	0	**0**	0	0	0	0
Community/Public	**0**	0	0	0	0	**0**	0	0	0	0	**0**	0	0	0	0

Participant 226:

Profile: Male, Hispanic, between 21-39 years old, prefers English, completed high school

Household Composition: No young children (<5), one older child (6-17), two adults (18-65), no seniors (>65)

Work and Transportation: Homemaker or works at home, one household car

Table A. Hours and Percent of Day by Microenvironment, Travel Mode and Proximity to Traffic and Truck Routes

	Day 2		Day 3	
	Hours	%Time	Hours	%Time
Microenvironment				
Indoors	19.0	79.1%	19.4	80.9%
Outdoors	3.1	12.9%	2.4	10.1%
In-Vehicle	1.9	8.1%	2.2	9.0%
Travel & Mode				
Not Traveling	22.1	92.1%	21.9	91.4%
Walking	0.0	0.0%	0.0	0.0%
Biking	0.0	0.0%	0.0	0.0%
Transit Travel	0.0	0.0%	0.0	0.0%
Vehicle Travel	1.9	7.9%	2.1	8.6%
Traffic Level within 200m				
Low	20.7	86.3%	20.5	85.5%
Medium	3.2	13.2%	3.0	12.6%
High	0.1	0.5%	0.5	2.0%
Truck Route within 200m				
No Nearby Truck Route	23.2	96.9%	23.1	96.2%
Nearby Truck Route	0.8	3.1%	0.9	3.8%

Table B. Unique Trips by Destination Type

	Day 2					Day 3				
Description	**Total**	**Walking**	**Biking**	**Transit**	**Vehicle**	**Total**	**Walking**	**Biking**	**Transit**	**Vehicle**
Total	**16**	**0**	**0**	**0**	**16**	**13**	**0**	**0**	**0**	**13**
Home	**6**	0	0	0	6	**5**	0	0	0	5
Work	**0**	0	0	0	0	**0**	0	0	0	0
Education	**0**	0	0	0	0	**0**	0	0	0	0
Volunteer	**0**	0	0	0	0	**0**	0	0	0	0
Pickup-Dropoff	**1**	0	0	0	1	**2**	0	0	0	2
Dining/Eating	**0**	0	0	0	0	**0**	0	0	0	0
Shopping/Retail	**3**	0	0	0	3	**0**	0	0	0	0
Services	**1**	0	0	0	1	**2**	0	0	0	2
Recreational/Exercise	**0**	0	0	0	0	**0**	0	0	0	0
Residential Visit	**1**	0	0	0	1	**0**	0	0	0	0
Community/Public	**4**	0	0	0	4	**4**	0	0	0	4

Participant 227:

Profile: Female, Hispanic, between 40-65 years old, prefers Spanish, completed less than high school
Household Composition: One young children (<5), three older children (6-17), two adults (18-65), no seniors (>65)
Work and Transportation: Works at home / homemaker, one household car

Table A. Hours and Percent of Day by Microenvironment, Travel Mode and Proximity to Traffic and Truck Routes

	Day 1		Day 2		Day 3	
	Hours	**%Time**	**Hours**	**%Time**	**Hours**	**%Time**
Microenvironment						
Indoors	22.8	95.2%	23.1	96.1%	22.0	91.6%
Outdoors	1.2	4.8%	0.9	3.9%	2.0	8.4%
In-Vehicle	0	0.0%	0.0	0.0%	0.0	0.0%
Travel & Mode						
Not Traveling	23.3	96.9%	23.1	96.4%	22.6	94.1%
Walking	0.7	3.1%	0.9	3.6%	1.4	5.9%
Biking	0	0.0%	0.0	0.0%	0.0	0.0%
Transit Travel	0	0.0%	0.0	0.0%	0.0	0.0%
Vehicle Travel	0	0.0%	0.0	0.0%	0.0	0.0%
Traffic Level within 200m						
Low	24	100.0%	24.0	100.0%	24.0	100.0%
Medium	0	0.0%	0.0	0.0%	0.0	0.0%
High	0	0.0%	0.0	0.0%	0.0	0.0%
Truck Route within 200m						
No Nearby Truck Route	24	100.0%	24.0	100.0%	22.4	93.4%
Nearby Truck Route	0	0.0%	0.0	0.0%	1.6	6.6%

Table B. Unique Trips by Destination Type

	Day 1					Day 2					Day 3				
Description	**Total**	**Walking**	**Biking**	**Transit**	**Vehicle**	**Total**	**Walking**	**Biking**	**Transit**	**Vehicle**	**Total**	**Walking**	**Biking**	**Transit**	**Vehicle**
Total	**8**	**8**	**0**	**0**	**0**	**8**	**8**	**0**	**0**	**0**	**14**	**14**	**0**	**0**	**0**
Home	**3**	3	0	0	0	**4**	4	0	0	0	**2**	2	0	0	0
Work	**0**	0	0	0	0	**0**	0	0	0	0	**0**	0	0	0	0
Education	**0**	0	0	0	0	**0**	0	0	0	0	**0**	0	0	0	0
Volunteer	**1**	1	0	0	0	**1**	1	0	0	0	**0**	0	0	0	0
Pickup-Dropoff	**1**	1	0	0	0	**3**	3	0	0	0	**1**	1	0	0	0
Dining/Eating	**0**	0	0	0	0	**0**	0	0	0	0	**1**	1	0	0	0
Shopping	**2**	2	0	0	0	**0**	0	0	0	0	**4**	4	0	0	0
Services	**1**	1	0	0	0	**0**	0	0	0	0	**2**	2	0	0	0
Recreational/Exercise	**0**	0	0	0	0	**0**	0	0	0	0	**0**	0	0	0	0
Residential Visit	**0**	0	0	0	0	**0**	0	0	0	0	**4**	4	0	0	0
Community/Public	**0**	0	0	0	0	**0**	0	0	0	0	**0**	0	0	0	0

Participant 228:

Profile: Male, Hispanic, between 40-65 years old, prefers English, completed some college

Household Composition: No young children (<5), no older children (6-17), one adult (18-65), no seniors (>65)

Work and Transportation: Works at home / homemaker, no household car

Table A. Hours and Percent of Day by Microenvironment, Travel Mode and Proximity to Traffic and Truck Routes

	Day 1		Day 2		Day 3	
	Hours	**%Time**	**Hours**	**%Time**	**Hours**	**%Time**
Microenvironment						
Indoors	20.7	86.1%	21.3	88.8%	19.2	80.1%
Outdoors	3.3	13.9%	1.5	6.2%	4.8	19.9%
In-Vehicle	0	0.0%	1.2	5.0%	0.0	0.0%
Travel & Mode						
Not Traveling	22.2	92.3%	22.0	91.8%	22.0	91.8%
Walking	0.9	3.6%	0.8	3.2%	0.2	0.7%
Biking	1	4.1%	0.0	0.0%	1.8	7.5%
Transit Travel	0	0.0%	0.0	0.0%	0.0	0.0%
Vehicle Travel	0	0.0%	1.2	5.0%	0.0	0.0%
Traffic Level within 200m						
Low	23.9	99.7%	23.8	99.2%	24.0	100.0%
Medium	0.1	0.3%	0.2	0.8%	0.0	0.0%
High	0	0.0%	0.0	0.0%	0.0	0.0%
Truck Route within 200m						
No Nearby Truck Route	2.6	10.7%	2.7	11.1%	3.2	13.2%
Nearby Truck Route	21.4	89.3%	21.3	88.9%	20.8	86.8%

Table B. Unique Trips by Destination Type

	Day 1					Day 2					Day 3				
Description	**Total**	**Walking**	**Biking**	**Transit**	**Vehicle**	**Total**	**Walking**	**Biking**	**Transit**	**Vehicle**	**Total**	**Walking**	**Biking**	**Transit**	**Vehicle**
Total	**14**	**4**	**10**	**0**	**0**	**10**	**6**	**0**	**0**	**4**	**21**	**4**	**17**	**0**	**0**
Home	**4**	1	3	0	0	**2**	2	0	0	0	**3**	0	3	0	0
Work	**4**	0	4	0	0	**3**	1	0	0	2	**9**	0	9	0	0
Education	**0**	0	0	0	0	**0**	0	0	0	0	**0**	0	0	0	0
Volunteer	**0**	0	0	0	0	**0**	0	0	0	0	**0**	0	0	0	0
Pickup-Dropoff	**0**	0	0	0	0	**1**	1	0	0	0	**0**	0	0	0	0
Dining/Eating	**0**	0	0	0	0	**0**	0	0	0	0	**0**	0	0	0	0
Shopping	**4**	1	3	0	0	**1**	0	0	0	1	**1**	0	1	0	0
Services	**0**	0	0	0	0	**0**	0	0	0	0	**0**	0	0	0	0
Recreational/Exercise	**1**	1	0	0	0	**0**	0	0	0	0	**0**	0	0	0	0
Residential Visit	**1**	1	0	0	0	**3**	2	0	0	1	**8**	4	4	0	0
Community/Public	**0**	0	0	0	0	**0**	0	0	0	0	**0**	0	0	0	0

Participant 300:

Profile: Female, Hispanic, between 21-39 years old, prefers Spanish, completed high school

Household Composition: One young child (<5), two older children (6-17), two adults (18-65), no seniors (>65)

Work and Transportation: Works away from home part time / homemaker, two household cars

Table A. Hours and Percent of Day by Microenvironment, Travel Mode and Proximity to Traffic and Truck Routes

	Day 1		Day 2		Day 3	
	Hours	**%Time**	**Hours**	**%Time**	**Hours**	**%Time**
Microenvironment						
Indoors	20.7	86.4%	20.9	87.3%	21.0	87.4%
Outdoors	0.7	2.9%	0.9	3.9%	0.4	1.6%
In-Vehicle	2.6	10.7%	2.1	8.8%	2.6	10.9%
Travel & Mode						
Not Traveling	22.5	93.7%	22.5	93.6%	22.4	93.4%
Walking	0	0.0%	0.0	0.0%	0.0	0.0%
Biking	0	0.0%	0.0	0.0%	0.0	0.0%
Transit Travel	0	0.0%	0.0	0.0%	0.0	0.0%
Vehicle Travel	1.5	6.3%	1.5	6.4%	1.6	6.6%
Traffic Level within 200m						
Low	23.4	97.5%	23.6	98.2%	21.9	91.4%
Medium	0	0.0%	0.0	0.2%	1.7	6.9%
High	0.6	2.5%	0.4	1.6%	0.4	1.7%
Truck Route within 200m						
No Nearby Truck Route	23	95.8%	23.1	96.3%	22.0	91.6%
Nearby Truck Route	1	4.2%	0.9	3.7%	2.0	8.4%

Table B. Unique Trips by Destination Type

	Day 1					Day 2					Day 3				
Description	**Total**	**Walking**	**Biking**	**Transit**	**Vehicle**	**Total**	**Walking**	**Biking**	**Transit**	**Vehicle**	**Total**	**Walking**	**Biking**	**Transit**	**Vehicle**
Total	**21**	**0**	**0**	**0**	**19**	**16**	**0**	**0**	**0**	**16**	**21**	**0**	**0**	**0**	**21**
Home	**5**	0	0	0	5	**5**	0	0	0	5	**5**	0	0	0	5
Work	**0**	0	0	0	0	**0**	0	0	0	0	**0**	0	0	0	0
Education	**0**	0	0	0	0	**1**	0	0	0	1	**0**	0	0	0	0
Volunteer	**0**	0	0	0	0	**0**	0	0	0	0	**0**	0	0	0	0
Pickup-Dropoff	**5**	0	0	0	5	**4**	0	0	0	4	**5**	0	0	0	5
Dining/Eating	**3**	0	0	0	3	**1**	0	0	0	1	**2**	0	0	0	2
Shopping/Retail	**1**	0	0	0	1	**4**	0	0	0	4	**4**	0	0	0	4
Services	**3**	0	0	0	3	**1**	0	0	0	1	**2**	0	0	0	2
Recreational/Exercise	**0**	0	0	0	0	**0**	0	0	0	0	**0**	0	0	0	0
Residential Visit	**2**	0	0	0	2	**0**	0	0	0	0	**3**	0	0	0	3
Community/Public	**2**	0	0	0	2	**2**	0	0	0	2	**0**	0	0	0	0

Participant 301:

Profile: Female, Hispanic, between 40-65 years old, prefers Spanish, completed some college

Household Composition: No young children (<5), no older children (6-17), two adults (18-65), no seniors (>65)

Work and Transportation: Works away from home / student, one household car

Table A. Hours and Percent of Day by Microenvironment, Travel Mode and Proximity to Traffic and Truck Routes

	Day 1		Day 2	
	Hours	%Time	Hours	%Time
Microenvironment				
Indoors	0	0.0%	0.0	0.0%
Outdoors	23.3	97.1%	23.7	98.7%
In-Vehicle	0.3	1.4%	0.3	1.3%
Travel & Mode				
Not Traveling	0.3	1.5%	0.0	0.0%
Walking	23.5	98.0%	23.7	98.7%
Biking	0.1	0.6%	0.3	1.3%
Transit Travel	0	0.0%	0.0	0.0%
Vehicle Travel	0.2	0.9%	0.0	0.0%
Traffic Level within 200m				
Low	0.1	0.5%	0.0	0.0%
Medium	14.7	61.2%	24.0	100.0%
High	9.3	38.8%	0.0	0.0%
Truck Route within 200m				
No Nearby Truck Route	0	0.0%	0.0	0.0%
Nearby Truck Route	23.9	99.6%	23.8	99.1%

Table B. Unique Trips by Destination Type

	Day 1					Day 2				
Description	**Total**	**Walking**	**Biking**	**Transit**	**Vehicle**	**Total**	**Walking**	**Biking**	**Transit**	**Vehicle**
Total	**4**	**2**	**0**	**1**	**1**	**3**	**3**	**0**	**0**	**0**
Home	**1**	0	0	0	1	**1**	1	0	0	0
Work	**2**	1	0	1	0	**0**	0	0	0	0
Education	**1**	1	0	0	0	**0**	0	0	0	0
Volunteer	**0**	0	0	0	0	**0**	0	0	0	0
Pickup-Dropoff	**0**	0	0	0	0	**0**	0	0	0	0
Dining/Eating	**0**	0	0	0	0	**0**	0	0	0	0
Shopping	**0**	0	0	0	0	**1**	1	0	0	0
Services	**0**	0	0	0	0	**1**	1	0	0	0
Recreational/Exercise	**0**	0	0	0	0	**0**	0	0	0	0
Residential Visit	**0**	0	0	0	0	**0**	0	0	0	0
Community/Public	**0**	0	0	0	0	**0**	0	0	0	0

Participant 302:

Profile: Female, Hispanic, between 40-65 years old, prefers Spanish, completed less than high school

Household Composition: One young child (<5), three older children (6-17), two adults (18-65), no seniors (>65)

Work and Transportation: Works at home / homemaker / volunteer, two household cars

Table A. Hours and Percent of Day by Microenvironment, Travel Mode and Proximity to Traffic and Truck Routes

	Day 1		Day 2		Day 3	
	Hours	%Time	Hours	%Time	Hours	%Time
Microenvironment						
Indoors	23	95.8%	22.6	94.1%	21.5	89.4%
Outdoors	1	4.1%	1.3	5.4%	2.5	10.6%
In-Vehicle	0	0.2%	0.1	0.5%	0.0	0.0%
Travel & Mode						
Not Traveling	23.2	96.7%	23.4	97.4%	23.2	96.9%
Walking	0.8	3.1%	0.5	2.0%	0.8	3.1%
Biking	0	0.0%	0.0	0.0%	0.0	0.0%
Transit Travel	0	0.0%	0.0	0.0%	0.0	0.0%
Vehicle Travel	0	0.1%	0.1	0.5%	0.0	0.0%
Traffic Level within 200m						
Low	24	100.0%	24.0	100.0%	24.0	100.0%
Medium	0	0.0%	0.0	0.0%	0.0	0.0%
High	0	0.0%	0.0	0.0%	0.0	0.0%
Truck Route within 200m						
No Nearby Truck Route	24	100.0%	23.5	98.0%	24.0	100.0%
Nearby Truck Route	0	0.0%	0.5	2.0%	0.0	0.0%

Table B. Unique Trips by Destination Type

	Day 1					Day 2					Day 3				
Description	**Total**	**Walking**	**Biking**	**Transit**	**Vehicle**	**Total**	**Walking**	**Biking**	**Transit**	**Vehicle**	**Total**	**Walking**	**Biking**	**Transit**	**Vehicle**
Total	**6**	**5**	**0**	**0**	**1**	**5**	**2**	**0**	**0**	**3**	**7**	**7**	**0**	**0**	**0**
Home	**2**	1	0	0	1	**2**	1	0	0	1	**3**	3	0	0	0
Work	**0**	0	0	0	0	**0**	0	0	0	0	**0**	0	0	0	0
Education	**1**	1	0	0	0	**0**	0	0	0	0	**0**	0	0	0	0
Volunteer	**0**	0	0	0	0	**0**	0	0	0	0	**0**	0	0	0	0
Pickup-Dropoff	**1**	1	0	0	0	**1**	1	0	0	0	**2**	2	0	0	0
Dining/Eating	**0**	0	0	0	0	**0**	0	0	0	0	**0**	0	0	0	0
Shopping	**1**	1	0	0	0	**1**	0	0	0	1	**0**	0	0	0	0
Services	**0**	0	0	0	0	**0**	0	0	0	0	**0**	0	0	0	0
Recreational/Exercise	**0**	0	0	0	0	**0**	0	0	0	0	**2**	2	0	0	0
Residential Visit	**1**	1	0	0	0	**1**	0	0	0	1	**0**	0	0	0	0
Community/Public	**0**	0	0	0	0	**0**	0	0	0	0	**0**	0	0	0	0

Participant 303:

Profile: Female, Hispanic, between 40-65 years old, prefers Spanish, completed less than high school

Household Composition: One young child (<5), two older children (6-17), two adults (18-65), no seniors (>65)

Work and Transportation: Works at home / homemaker, one household car

Table A. Hours and Percent of Day by Microenvironment, Travel Mode and Proximity to Traffic and Truck Routes

	Day 1		Day 3	
	Hours	**%Time**	**Hours**	**%Time**
Microenvironment				
Indoors	22.5	93.6%	20.2	84.2%
Outdoors	1.1	4.6%	2.0	8.4%
In-Vehicle	0.4	1.8%	1.8	7.4%
Travel & Mode				
Not Traveling	23	95.9%	21.8	90.8%
Walking	0.8	3.3%	0.6	2.7%
Biking	0	0.0%	0.0	0.0%
Transit Travel	0	0.0%	0.0	0.0%
Vehicle Travel	0.2	0.9%	1.6	6.5%
Traffic Level within 200m				
Low	24	100.0%	22.1	92.1%
Medium	0	0.0%	0.8	3.5%
High	0	0.0%	1.0	4.4%
Truck Route within 200m				
No Nearby Truck Route	22.7	94.6%	23.4	97.5%
Nearby Truck Route	1.3	5.4%	0.6	2.5%

Table B. Unique Trips by Destination Type

	Day 1					Day 3				
Description	**Total**	**Walking**	**Biking**	**Transit**	**Vehicle**	**Total**	**Walking**	**Biking**	**Transit**	**Vehicle**
Total	**7**	**5**	**0**	**0**	**2**	**12**	**5**	**0**	**0**	**7**
Home	**3**	2	0	0	1	**2**	1	0	0	1
Work	**0**	0	0	0	0	**0**	0	0	0	0
Education	**0**	0	0	0	0	**0**	0	0	0	0
Volunteer	**0**	0	0	0	0	**0**	0	0	0	0
Pickup-Dropoff	**1**	1	0	0	0	**2**	2	0	0	0
Dining/Eating	**0**	0	0	0	0	**0**	0	0	0	0
Shopping/Retail	**2**	1	0	0	1	**5**	2	0	0	3
Services	**0**	0	0	0	0	**1**	0	0	0	1
Recreational/Exercise	**0**	0	0	0	0	**0**	0	0	0	0
Residential Visit	**0**	0	0	0	0	**2**	0	0	0	2
Community/Public	**1**	1	0	0	0	**0**	0	0	0	0

Participant 304:

Profile: Male, Non-Hispanic, between 40-65 years old, prefers English, completed B.A. or higher

Household Composition: One young child (<5), two older children (6-17), four adults (18-65), no seniors (>65)

Work and Transportation: Works at home and away from home, three household cars

Table A. Hours and Percent of Day by Microenvironment, Travel Mode and Proximity to Traffic and Truck Routes

	Day 1		Day 2		Day 3	
	Hours	**%Time**	**Hours**	**%Time**	**Hours**	**%Time**
Microenvironment						
Indoors	21.5	89.8%	20.3	84.5%	20.5	85.5%
Outdoors	1	4.1%	2.0	8.2%	0.6	2.3%
In-Vehicle	1.5	6.2%	1.8	7.3%	2.9	12.2%
Travel & Mode						
Not Traveling	22.5	93.8%	22.9	95.4%	21.7	90.4%
Walking	0.1	0.3%	0.0	0.0%	0.0	0.1%
Biking	0	0.0%	0.0	0.0%	0.0	0.0%
Transit Travel	0	0.0%	0.0	0.0%	0.0	0.0%
Vehicle Travel	1.4	5.8%	1.1	4.6%	2.3	9.5%
Traffic Level within 200m						
Low	0.3	1.4%	0.6	2.7%	2.4	10.0%
Medium	21.3	88.8%	23.3	97.3%	21.6	89.9%
High	2.3	9.8%	0.0	0.1%	0.0	0.1%
Truck Route within 200m						
No Nearby Truck Route	21.7	90.2%	22.5	93.9%	23.8	99.4%
Nearby Truck Route	2.3	9.8%	1.5	6.1%	0.2	0.6%

Table B. Unique Trips by Destination Type

	Day 1					Day 2					Day 3				
Description	**Total**	**Walking**	**Biking**	**Transit**	**Vehicle**	**Total**	**Walking**	**Biking**	**Transit**	**Vehicle**	**Total**	**Walking**	**Biking**	**Transit**	**Vehicle**
Total	**14**	**2**	**0**	**0**	**12**	**9**	**0**	**0**	**0**	**9**	**17**	**1**	**0**	**0**	**16**
Home	**3**	0	0	0	3	**2**	0	0	0	2	**4**	0	0	0	4
Work	**4**	1	0	0	3	**2**	0	0	0	2	**2**	0	0	0	2
Education	**0**	0	0	0	0	**0**	0	0	0	0	**0**	0	0	0	0
Volunteer	**0**	0	0	0	0	**0**	0	0	0	0	**0**	0	0	0	0
Pickup-Dropoff	**0**	0	0	0	0	**0**	0	0	0	0	**4**	0	0	0	4
Dining/Eating	**2**	1	0	0	1	**1**	0	0	0	1	**2**	1	0	0	1
Shopping/Retail	**2**	0	0	0	2	**2**	0	0	0	2	**0**	0	0	0	0
Services	**2**	0	0	0	2	**0**	0	0	0	0	**1**	0	0	0	1
Recreational/Exercise	**0**	0	0	0	0	**0**	0	0	0	0	**0**	0	0	0	0
Residential Visit	**1**	0	0	0	1	**1**	0	0	0	1	**4**	0	0	0	4
Community/Public	**0**	0	0	0	0	**1**	0	0	0	1	**0**	0	0	0	0

Participant 305:

Profile: Female, Hispanic, between 40-65 years old, prefers Spanish, completed less than high school

Household Composition: No young children (<5), three older children (6-17), three adults (18-65), no seniors (>65)

Work and Transportation: Homemaker / student, two household cars

Table A. Hours and Percent of Day by Microenvironment, Travel Mode and Proximity to Traffic and Truck Routes

	Day 1		Day 2		Day 3	
	Hours	**%Time**	**Hours**	**%Time**	**Hours**	**%Time**
Microenvironment						
Indoors	16.5	68.5%	21.6	90.0%	22.7	94.8%
Outdoors	0.2	0.9%	1.4	5.8%	0.4	1.5%
In-Vehicle	7.3	30.5%	1.0	4.2%	0.9	3.8%
Travel & Mode						
Not Traveling	16.8	69.8%	22.1	92.1%	23.1	96.3%
Walking	0	0.0%	1.0	4.0%	0.0	0.0%
Biking	0	0.0%	0.0	0.0%	0.0	0.0%
Transit Travel	0	0.0%	0.0	0.0%	0.0	0.0%
Vehicle Travel	7.2	30.2%	0.9	3.9%	0.9	3.7%
Traffic Level within 200m						
Low	23.9	99.7%	23.8	99.0%	22.5	93.7%
Medium	0.1	0.3%	0.2	1.0%	0.6	2.5%
High	0	0.0%	0.0	0.0%	0.9	3.8%
Truck Route within 200m						
No Nearby Truck Route	0.8	3.4%	4.0	16.5%	3.0	12.5%
Nearby Truck Route	23.2	96.6%	20.0	83.5%	21.0	87.5%

Table B. Unique Trips by Destination Type

	Day 1					Day 2					Day 3				
Description	**Total**	**Walking**	**Biking**	**Transit**	**Vehicle**	**Total**	**Walking**	**Biking**	**Transit**	**Vehicle**	**Total**	**Walking**	**Biking**	**Transit**	**Vehicle**
Total	**13**	**0**	**0**	**0**	**13**	**13**	**1**	**0**	**0**	**12**	**7**	**0**	**0**	**0**	**7**
Home	**4**	0	0	0	4	**5**	0	0	0	5	**3**	0	0	0	3
Work	**0**	0	0	0	0	**0**	0	0	0	0	**0**	0	0	0	0
Education	**0**	0	0	0	0	**1**	0	0	0	1	**0**	0	0	0	0
Volunteer	**0**	0	0	0	0	**0**	0	0	0	0	**0**	0	0	0	0
Pickup-Dropoff	**4**	0	0	0	4	**4**	0	0	0	4	**1**	0	0	0	1
Dining/Eating	**0**	0	0	0	0	**0**	0	0	0	0	**0**	0	0	0	0
Shopping/Retail	**3**	0	0	0	3	**1**	0	0	0	1	**2**	0	0	0	2
Services	**1**	0	0	0	1	**0**	0	0	0	0	**0**	0	0	0	0
Recreational/Exercise	**0**	0	0	0	0	**1**	1	0	0	0	**0**	0	0	0	0
Residential Visit	**1**	0	0	0	1	**1**	0	0	0	1	**1**	0	0	0	1
Community/Public	**0**	0	0	0	0	**0**	0	0	0	0	**0**	0	0	0	0

Participant 306:

Profile: Male, Non-Hispanic, between 21-39 years old, prefers English, completed B.A. or higher

Household Composition: No young children (<5), no older children (6-17), three adults (18-65), no seniors (>65)

Work and Transportation: Looking for work, three household cars

Table A. Hours and Percent of Day by Microenvironment, Travel Mode and Proximity to Traffic and Truck Routes

	Day 1		Day 2		Day 3	
	Hours	**%Time**	**Hours**	**%Time**	**Hours**	**%Time**
Microenvironment						
Indoors	20.5	85.6%	22.2	92.4%	21.3	88.7%
Outdoors	2.2	9.2%	1.0	4.0%	2.3	9.8%
In-Vehicle	1.3	5.2%	0.9	3.6%	0.4	1.5%
Travel & Mode						
Not Traveling	22.3	93.0%	22.9	95.2%	23.6	98.3%
Walking	0.4	1.8%	0.3	1.2%	0.1	0.2%
Biking	0	0.0%	0.0	0.0%	0.0	0.0%
Transit Travel	0	0.0%	0.0	0.0%	0.0	0.0%
Vehicle Travel	1.3	5.2%	0.9	3.6%	0.4	1.5%
Traffic Level within 200m						
Low	22.9	95.5%	21.6	89.9%	16.7	69.7%
Medium	0.9	3.8%	1.9	8.0%	7.3	30.3%
High	0.2	0.8%	0.5	2.1%	0.0	0.0%
Truck Route within 200m						
No Nearby Truck Route	23.8	99.4%	23.8	99.1%	24.0	100.0%
Nearby Truck Route	0.2	0.6%	0.2	0.9%	0.0	0.0%

Table B. Unique Trips by Destination Type

	Day 1					Day 2					Day 3				
Description	**Total**	**Walking**	**Biking**	**Transit**	**Vehicle**	**Total**	**Walking**	**Biking**	**Transit**	**Vehicle**	**Total**	**Walking**	**Biking**	**Transit**	**Vehicle**
Total	**7**	**3**	**0**	**0**	**4**	**7**	**3**	**0**	**0**	**4**	**4**	**1**	**0**	**0**	**3**
Home	**2**	1	0	0	1	**2**	1	0	0	1	**1**	0	0	0	1
Work	**0**	0	0	0	0	**0**	0	0	0	0	**0**	0	0	0	0
Education	**0**	0	0	0	0	**0**	0	0	0	0	**0**	0	0	0	0
Volunteer	**0**	0	0	0	0	**0**	0	0	0	0	**0**	0	0	0	0
Pickup-Dropoff	**0**	0	0	0	0	**0**	0	0	0	0	**0**	0	0	0	0
Dining/Eating	**1**	1	0	0	0	**0**	0	0	0	0	**1**	0	0	0	1
Shopping/Retail	**0**	0	0	0	0	**1**	0	0	0	1	**0**	0	0	0	0
Services	**1**	1	0	0	0	**0**	0	0	0	0	**0**	0	0	0	0
Recreational/Exercise	**3**	0	0	0	3	**2**	1	0	0	1	**0**	0	0	0	0
Residential Visit	**0**	0	0	0	0	**2**	1	0	0	1	**2**	1	0	0	1
Community/Public	**0**	0	0	0	0	**0**	0	0	0	0	**0**	0	0	0	0

Participant 307:

Profile: Female, Hispanic, between 40-65 years old, prefers Spanish, completed some college

Household Composition: One young child (<5), two older children (6-17), two adults (18-65), no seniors (>65)

Work and Transportation: Student / homemaker / volunteer, one household car

Table A. Hours and Percent of Day by Microenvironment, Travel Mode and Proximity to Traffic and Truck Routes

	Day 1		Day 2		Day 3	
	Hours	**%Time**	**Hours**	**%Time**	**Hours**	**%Time**
Microenvironment						
Indoors	22.3	93.0%	22.0	91.7%	21.6	89.9%
Outdoors	1.4	5.6%	1.6	6.6%	2.0	8.5%
In-Vehicle	0.3	1.4%	0.4	1.7%	0.4	1.6%
Travel & Mode						
Not Traveling	23	95.7%	22.5	93.8%	22.4	93.4%
Walking	0.8	3.1%	1.1	4.5%	1.3	5.4%
Biking	0	0.0%	0.0	0.0%	0.0	0.0%
Transit Travel	0	0.0%	0.4	1.7%	0.0	0.0%
Vehicle Travel	0.3	1.2%	0.0	0.0%	0.3	1.2%
Traffic Level within 200m						
Low	24	99.9%	23.7	98.6%	24.0	100.0%
Medium	0	0.1%	0.3	1.4%	0.0	0.0%
High	0	0.0%	0.0	0.0%	0.0	0.0%
Truck Route within 200m						
No Nearby Truck Route	3.3	13.8%	5.4	22.4%	5.2	21.8%
Nearby Truck Route	20.7	86.2%	18.6	77.6%	18.8	78.2%

Table B. Unique Trips by Destination Type

	Day 1					Day 2					Day 3				
Description	**Total**	**Walking**	**Biking**	**Transit**	**Vehicle**	**Total**	**Walking**	**Biking**	**Transit**	**Vehicle**	**Total**	**Walking**	**Biking**	**Transit**	**Vehicle**
Total	**9**	**7**	**0**	**0**	**2**	**13**	**10**	**0**	**3**	**0**	**16**	**11**	**0**	**0**	**5**
Home	**4**	3	0	0	1	**6**	5	0	1	0	**4**	3	0	0	1
Work	**0**	0	0	0	0	**0**	0	0	0	0	**0**	0	0	0	0
Education	**0**	0	0	0	0	**0**	0	0	0	0	**0**	0	0	0	0
Volunteer	**1**	1	0	0	0	**0**	0	0	0	0	**1**	1	0	0	0
Pickup-Dropoff	**2**	2	0	0	0	**3**	3	0	0	0	**3**	2	0	0	1
Dining/Eating	**0**	0	0	0	0	**0**	0	0	0	0	**0**	0	0	0	0
Shopping	**1**	1	0	0	0	**0**	0	0	0	0	**5**	3	0	0	2
Services	**1**	0	0	0	1	**0**	0	0	0	0	**2**	1	0	0	1
Recreational/Exercise	**0**	0	0	0	0	**0**	0	0	0	0	**0**	0	0	0	0
Residential Visit	**0**	0	0	0	0	**4**	2	0	2	0	**1**	1	0	0	0
Community/Public	**0**	0	0	0	0	**0**	0	0	0	0	**0**	0	0	0	0

Participant 308:

Profile: Female, Hispanic, between 21-39 years old, prefers Spanish, completed high school

Household Composition: One young child (<5), two older children (6-17), two adults (18-65), no seniors (>65)

Work and Transportation: Works at home / homemaker, two household cars

Table A. Hours and Percent of Day by Microenvironment, Travel Mode and Proximity to Traffic and Truck Routes

	Day 1		Day 2		Day 3	
	Hours	**%Time**	**Hours**	**%Time**	**Hours**	**%Time**
Microenvironment						
Indoors	21.1	87.7%	22.0	91.5%	22.0	91.6%
Outdoors	0.5	2.2%	0.2	0.8%	0.2	0.7%
In-Vehicle	2.4	10.1%	1.8	7.7%	1.8	7.6%
Travel & Mode						
Not Traveling	22.7	94.7%	23.2	96.5%	23.3	96.9%
Walking	0.3	1.3%	0.0	0.0%	0.0	0.0%
Biking	0	0.0%	0.0	0.0%	0.0	0.0%
Transit Travel	0	0.0%	0.0	0.0%	0.0	0.0%
Vehicle Travel	0.9	3.9%	0.8	3.5%	0.7	3.1%
Traffic Level within 200m						
Low	23.9	99.5%	23.9	99.6%	23.9	99.6%
Medium	0.1	0.5%	0.1	0.4%	0.1	0.4%
High	0	0.0%	0.0	0.0%	0.0	0.0%
Truck Route within 200m						
No Nearby Truck Route	22.8	94.8%	23.5	97.9%	23.1	96.4%
Nearby Truck Route	1.2	5.2%	0.5	2.1%	0.9	3.6%

Table B. Unique Trips by Destination Type

	Day 1					Day 2					Day 3				
Description	**Total**	**Walking**	**Biking**	**Transit**	**Vehicle**	**Total**	**Walking**	**Biking**	**Transit**	**Vehicle**	**Total**	**Walking**	**Biking**	**Transit**	**Vehicle**
Total	**14**	**4**	**0**	**0**	**10**	**10**	**0**	**0**	**0**	**10**	**8**	**0**	**0**	**0**	**8**
Home	**5**	1	0	0	4	**4**	0	0	0	4	**2**	0	0	0	2
Work	**0**	0	0	0	0	**0**	0	0	0	0	**0**	0	0	0	0
Education	**2**	0	0	0	2	**1**	0	0	0	1	**0**	0	0	0	0
Volunteer	**0**	0	0	0	0	**0**	0	0	0	0	**0**	0	0	0	0
Pickup-Dropoff	**4**	0	0	0	4	**5**	0	0	0	5	**4**	0	0	0	4
Dining/Eating	**0**	0	0	0	0	**0**	0	0	0	0	**0**	0	0	0	0
Shopping	**3**	3	0	0	0	**0**	0	0	0	0	**1**	0	0	0	1
Services	**0**	0	0	0	0	**0**	0	0	0	0	**0**	0	0	0	0
Recreational/Exercise	**0**	0	0	0	0	**0**	0	0	0	0	**0**	0	0	0	0
Residential Visit	**0**	0	0	0	0	**0**	0	0	0	0	**1**	0	0	0	1
Community/Public	**0**	0	0	0	0	**0**	0	0	0	0	**0**	0	0	0	0

Participant 309:

Profile: Female, Hispanic, between 21-39 years old, prefers Spanish, completed high school

Household Composition: No young children (<5), four older children (6-17), two adults (18-65), no seniors (>65)

Work and Transportation: Student / homemaker, one household car

Table A. Hours and Percent of Day by Microenvironment, Travel Mode and Proximity to Traffic and Truck Routes

	Day 1		Day 2		Day 3	
	Hours	%Time	Hours	%Time	Hours	%Time
Microenvironment						
Indoors	22.3	92.9%	21.3	88.8%	21.0	87.5%
Outdoors	1.7	7.1%	2.6	10.8%	1.7	7.0%
In-Vehicle	0	0.0%	0.1	0.4%	1.3	5.6%
Travel & Mode						
Not Traveling	22.4	93.4%	21.9	91.4%	22.3	92.9%
Walking	1.6	6.6%	2.0	8.3%	0.5	2.2%
Biking	0	0.0%	0.0	0.0%	0.0	0.0%
Transit Travel	0	0.0%	0.0	0.0%	0.0	0.0%
Vehicle Travel	0	0.0%	0.1	0.4%	1.2	5.0%
Traffic Level within 200m						
Low	23.4	97.7%	23.1	96.2%	19.1	79.4%
Medium	0.6	2.3%	0.9	3.8%	4.3	17.9%
High	0	0.0%	0.0	0.0%	0.7	2.7%
Truck Route within 200m						
No Nearby Truck Route	22.8	94.9%	23.0	95.7%	23.0	95.7%
Nearby Truck Route	1.2	5.1%	1.0	4.3%	1.0	4.3%

Table B. Unique Trips by Destination Type

	Day 1					Day 2					Day 3				
Description	**Total**	**Walking**	**Biking**	**Transit**	**Vehicle**	**Total**	**Walking**	**Biking**	**Transit**	**Vehicle**	**Total**	**Walking**	**Biking**	**Transit**	**Vehicle**
Total	**10**	**10**	**0**	**0**	**0**	**14**	**13**	**0**	**0**	**1**	**13**	**5**	**0**	**0**	**8**
Home	**3**	3	0	0	0	**4**	4	0	0	0	**3**	2	0	0	1
Work	**0**	0	0	0	0	**0**	0	0	0	0	**0**	0	0	0	0
Education	**1**	1	0	0	0	**1**	1	0	0	0	**0**	0	0	0	0
Volunteer	**1**	1	0	0	0	**1**	1	0	0	0	**0**	0	0	0	0
Pickup-Dropoff	**2**	2	0	0	0	**1**	1	0	0	0	**0**	0	0	0	0
Dining/Eating	**0**	0	0	0	0	**1**	1	0	0	0	**2**	1	0	0	1
Shopping/Retail	**2**	2	0	0	0	**6**	5	0	0	1	**6**	1	0	0	5
Services	**1**	1	0	0	0	**0**	0	0	0	0	**0**	0	0	0	0
Recreational/Exercise	**0**	0	0	0	0	**0**	0	0	0	0	**0**	0	0	0	0
Residential Visit	**0**	0	0	0	0	**0**	0	0	0	0	**2**	1	0	0	1
Community/Public	**0**	0	0	0	0	**0**	0	0	0	0	**0**	0	0	0	0

Participant 310:

Profile: Female, Hispanic, between 21-39 years old, prefers Spanish, completed less than high school

Household Composition: No young children (<5), three older children (6-17), two adults (18-65), no seniors (>65)

Work and Transportation: Homemaker and volunteer, one household car

Table A. Hours and Percent of Day by Microenvironment, Travel Mode and Proximity to Traffic and Truck Routes

	Day 1		Day 2		Day 3	
	Hours	%Time	Hours	%Time	Hours	%Time
Microenvironment						
Indoors	21.8	90.9%	22.0	91.5%	21.9	91.4%
Outdoors	2.2	9.1%	1.6	6.8%	1.5	6.5%
In-Vehicle	0	0.0%	0.4	1.7%	0.5	2.2%
Travel & Mode						
Not Traveling	22.5	93.9%	22.8	95.0%	22.7	94.8%
Walking	1.5	6.1%	0.9	3.7%	0.9	3.7%
Biking	0	0.0%	0.0	0.0%	0.0	0.0%
Transit Travel	0	0.0%	0.0	0.0%	0.0	0.0%
Vehicle Travel	0	0.0%	0.3	1.4%	0.4	1.5%
Traffic Level within 200m						
Low	3.5	14.6%	4.3	18.0%	5.0	20.7%
Medium	20.5	85.4%	19.7	82.0%	19.0	79.3%
High	0	0.0%	0.0	0.0%	0.0	0.0%
Truck Route within 200m						
No Nearby Truck Route	3.5	14.6%	4.3	18.1%	5.2	21.6%
Nearby Truck Route	20.5	85.4%	19.7	81.9%	18.8	78.4%

Table B. Unique Trips by Destination Type

	Day 1					Day 2					Day 3				
Description	**Total**	**Walking**	**Biking**	**Transit**	**Vehicle**	**Total**	**Walking**	**Biking**	**Transit**	**Vehicle**	**Total**	**Walking**	**Biking**	**Transit**	**Vehicle**
Total	**6**	**6**	**0**	**0**	**0**	**6**	**3**	**0**	**0**	**3**	**10**	**3**	**0**	**0**	**7**
Home	**2**	2	0	0	0	**2**	1	0	0	1	**3**	1	0	0	2
Work	**0**	0	0	0	0	**0**	0	0	0	0	**0**	0	0	0	0
Education	**0**	0	0	0	0	**0**	0	0	0	0	**0**	0	0	0	0
Volunteer	**1**	1	0	0	0	**1**	1	0	0	0	**1**	1	0	0	0
Pickup-Dropoff	**1**	1	0	0	0	**1**	1	0	0	0	**1**	1	0	0	0
Dining/Eating	**0**	0	0	0	0	**0**	0	0	0	0	**1**	0	0	0	1
Shopping	**0**	0	0	0	0	**2**	0	0	0	2	**2**	0	0	0	2
Services	**0**	0	0	0	0	**0**	0	0	0	0	**2**	0	0	0	2
Recreational/Exercise	**0**	0	0	0	0	**0**	0	0	0	0	**0**	0	0	0	0
Residential Visit	**2**	2	0	0	0	**0**	0	0	0	0	**0**	0	0	0	0
Community/Public	**0**	0	0	0	0	**0**	0	0	0	0	**0**	0	0	0	0

Participant 311:

Profile: Female, Hispanic, between 21-39 years old, prefers Spanish, completed high school

Household Composition: One young child (<5), three older children (6-17), two adults (18-65), no seniors (>65)

Work and Transportation: Student / working / homemaker / volunteer, two household cars

Table A. Hours and Percent of Day by Microenvironment, Travel Mode and Proximity to Traffic and Truck Routes

	Day 1		Day 2		Day 3	
	Hours	%Time	Hours	%Time	Hours	%Time
Microenvironment						
Indoors	21.2	88.5%	21.1	87.7%	21.9	91.4%
Outdoors	0.7	2.9%	2.1	8.7%	0.8	3.3%
In-Vehicle	2.1	8.5%	0.8	3.5%	1.3	5.3%
Travel & Mode						
Not Traveling	22.6	94.1%	22.7	94.4%	22.7	94.7%
Walking	0.2	0.6%	0.7	2.9%	0.3	1.3%
Biking	0	0.0%	0.0	0.0%	0.0	0.0%
Transit Travel	0	0.0%	0.0	0.0%	0.0	0.0%
Vehicle Travel	1.3	5.3%	0.6	2.6%	1.0	4.0%
Traffic Level within 200m						
Low	23.4	97.6%	23.8	99.2%	23.8	99.3%
Medium	0.6	2.4%	0.2	0.8%	0.2	0.7%
High	0	0.0%	0.0	0.0%	0.0	0.0%
Truck Route within 200m						
No Nearby Truck Route	23.4	97.6%	23.9	99.6%	22.9	95.3%
Nearby Truck Route	0.6	2.4%	0.1	0.4%	1.1	4.7%

Table B. Unique Trips by Destination Type

	Day 1					Day 2					Day 3				
Description	**Total**	**Walking**	**Biking**	**Transit**	**Vehicle**	**Total**	**Walking**	**Biking**	**Transit**	**Vehicle**	**Total**	**Walking**	**Biking**	**Transit**	**Vehicle**
Total	**14**	**2**	**0**	**0**	**12**	**12**	**7**	**0**	**0**	**5**	**12**	**4**	**0**	**0**	**8**
Home	**3**	0	0	0	3	**5**	3	0	0	2	**3**	1	0	0	2
Work	**0**	0	0	0	0	**0**	0	0	0	0	**0**	0	0	0	0
Education	**0**	0	0	0	0	**1**	1	0	0	0	**1**	1	0	0	0
Volunteer	**0**	0	0	0	0	**0**	0	0	0	0	**0**	0	0	0	0
Pickup-Dropoff	**5**	0	0	0	5	**3**	0	0	0	3	**5**	0	0	0	5
Dining/Eating	**1**	0	0	0	1	**0**	0	0	0	0	**0**	0	0	0	0
Shopping	**0**	0	0	0	0	**0**	0	0	0	0	**1**	0	0	0	1
Services	**5**	2	0	0	3	**3**	3	0	0	0	**2**	2	0	0	0
Recreational/Exercise	**0**	0	0	0	0	**0**	0	0	0	0	**0**	0	0	0	0
Residential Visit	**0**	0	0	0	0	**0**	0	0	0	0	**0**	0	0	0	0
Community/Public	**0**	0	0	0	0	**0**	0	0	0	0	**0**	0	0	0	0

Participant 313:

Profile: Male, Hispanic, between 40-65 years old, prefers Spanish, completed high school

Household Composition: No young children (<5), no older children (6-17), one adult (18-65), no seniors (>65)

Work and Transportation: Works away from home fulltime / homemaker, one household car

Table A. Hours and Percent of Day by Microenvironment, Travel Mode and Proximity to Traffic and Truck Routes

	Day 1		Day 2		Day 3	
	Hours	%Time	Hours	%Time	Hours	%Time
Microenvironment						
Indoors	17.3	72.1%	16.0	66.5%	19.8	82.4%
Outdoors	4.4	18.2%	4.1	17.1%	3.6	14.9%
In-Vehicle	2.3	9.7%	3.9	16.4%	0.7	2.7%
Travel & Mode						
Not Traveling	20	83.2%	20.4	84.9%	23.3	97.0%
Walking	0	0.0%	0.0	0.0%	0.1	0.3%
Biking	1.7	7.2%	0.0	0.0%	0.0	0.0%
Transit Travel	0	0.0%	0.0	0.0%	0.0	0.0%
Vehicle Travel	2.3	9.7%	3.6	15.1%	0.7	2.7%
Traffic Level within 200m						
Low	20.7	86.3%	11.6	48.2%	17.0	71.0%
Medium	1.4	5.7%	6.9	28.6%	0.2	0.9%
High	1.9	8.0%	5.6	23.2%	6.7	28.0%
Truck Route within 200m						
No Nearby Truck Route	5.7	23.8%	13.3	55.6%	7.3	30.5%
Nearby Truck Route	18.3	76.2%	10.7	44.4%	16.7	69.5%

Table B. Unique Trips by Destination Type

	Day 1					Day 2					Day 3				
Description	**Total**	**Walking**	**Biking**	**Transit**	**Vehicle**	**Total**	**Walking**	**Biking**	**Transit**	**Vehicle**	**Total**	**Walking**	**Biking**	**Transit**	**Vehicle**
Total	**11**	**0**	**3**	**0**	**8**	**18**	**0**	**0**	**0**	**18**	**6**	**2**	**0**	**0**	**4**
Home	**2**	0	1	0	1	**3**	0	0	0	3	**1**	0	0	0	1
Work	**3**	0	0	0	3	**5**	0	0	0	5	**0**	0	0	0	0
Education	**0**	0	0	0	0	**0**	0	0	0	0	**0**	0	0	0	0
Volunteer	**0**	0	0	0	0	**0**	0	0	0	0	**0**	0	0	0	0
Pickup-Dropoff	**0**	0	0	0	0	**1**	0	0	0	1	**0**	0	0	0	0
Dining/Eating	**2**	0	0	0	2	**4**	0	0	0	4	**1**	0	0	0	1
Shopping/Retail	**1**	0	0	0	1	**4**	0	0	0	4	**1**	1	0	0	0
Services	**1**	0	0	0	1	**0**	0	0	0	0	**2**	1	0	0	1
Recreational/Exercise	**2**	0	2	0	0	**1**	0	0	0	1	**1**	0	0	0	1
Residential Visit	**0**	0	0	0	0	**0**	0	0	0	0	**0**	0	0	0	0
Community/Public	**0**	0	0	0	0	**0**	0	0	0	0	**0**	0	0	0	0

Participant 314:

Profile: Female, Hispanic, between 40-65 years old, prefers Spanish, completed less than high school

Household Composition: One young child (<5), one older child (6-17), two adults (18-65), no seniors (>65)

Work and Transportation: Homemaker, two household cars

Table A. Hours and Percent of Day by Microenvironment, Travel Mode and Proximity to Traffic and Truck Routes

	Day 1		Day 2		Day 3	
	Hours	%Time	Hours	%Time	Hours	%Time
Microenvironment						
Indoors	19.1	79.4%	18.7	77.9%	20.1	83.6%
Outdoors	3.3	13.9%	3.5	14.8%	2.9	12.3%
In-Vehicle	1.6	6.7%	1.8	7.3%	1.0	4.1%
Travel & Mode						
Not Traveling	21.9	91.5%	20.4	85.0%	21.4	89.3%
Walking	0.5	1.9%	1.9	7.7%	1.6	6.6%
Biking	0	0.0%	0.0	0.0%	0.0	0.0%
Transit Travel	1	4.0%	0.2	1.0%	0.9	3.7%
Vehicle Travel	0.6	2.6%	1.5	6.3%	0.1	0.4%
Traffic Level within 200m						
Low	21.9	91.2%	21.2	88.3%	23.3	97.1%
Medium	0.5	2.1%	1.6	6.8%	0.2	0.8%
High	1.6	6.6%	1.2	5.0%	0.5	2.1%
Truck Route within 200m						
No Nearby Truck Route	22.1	92.1%	21.9	91.4%	23.1	96.1%
Nearby Truck Route	1.9	7.9%	2.1	8.6%	0.9	3.9%

Table B. Unique Trips by Destination Type

	Day 1					Day 2					Day 3				
Description	**Total**	**Walking**	**Biking**	**Transit**	**Vehicle**	**Total**	**Walking**	**Biking**	**Transit**	**Vehicle**	**Total**	**Walking**	**Biking**	**Transit**	**Vehicle**
Total	**16**	**8**	**0**	**5**	**3**	**17**	**10**	**0**	**2**	**5**	**16**	**10**	**0**	**5**	**1**
Home	**6**	3	0	2	1	**4**	2	0	0	2	**4**	2	0	1	1
Work	**0**	0	0	0	0	**0**	0	0	0	0	**0**	0	0	0	0
Education	**0**	0	0	0	0	**0**	0	0	0	0	**0**	0	0	0	0
Volunteer	**0**	0	0	0	0	**0**	0	0	0	0	**0**	0	0	0	0
Pickup-Dropoff	**6**	4	0	2	0	**6**	4	0	2	0	**6**	4	0	2	0
Dining/Eating	**0**	0	0	0	0	**1**	0	0	0	1	**0**	0	0	0	0
Shopping/Retail	**4**	1	0	1	2	**3**	2	0	0	1	**4**	2	0	2	0
Services	**0**	0	0	0	0	**1**	0	0	0	1	**0**	0	0	0	0
Recreational/Exercise	**0**	0	0	0	0	**1**	1	0	0	0	**1**	1	0	0	0
Residential Visit	**0**	0	0	0	0	**1**	1	0	0	0	**1**	1	0	0	0
Community/Public	**0**	0	0	0	0	**0**	0	0	0	0	**0**	0	0	0	0

Participant 315:

Profile: Female, Hispanic, between 21-39 years old, prefers Spanish, completed high school

Household Composition: One young child (<5), four older children (6-17), two adults (18-65), no seniors (>65)

Work and Transportation: Works at home / homemaker, two household cars

Table A. Hours and Percent of Day by Microenvironment, Travel Mode and Proximity to Traffic and Truck Routes

	Day 1		Day 2		Day 3	
	Hours	**%Time**	**Hours**	**%Time**	**Hours**	**%Time**
Microenvironment						
Indoors	21.1	88.1%	22.1	92.0%	22.7	94.7%
Outdoors	0.2	0.8%	0.8	3.2%	0.1	0.4%
In-Vehicle	2.7	11.1%	1.1	4.8%	1.2	4.8%
Travel & Mode						
Not Traveling	22.9	95.4%	23.6	98.2%	23.3	97.0%
Walking	0	0.0%	0.1	0.6%	0.0	0.0%
Biking	0	0.0%	0.0	0.0%	0.0	0.0%
Transit Travel	0	0.0%	0.0	0.0%	0.0	0.0%
Vehicle Travel	1.1	4.6%	0.3	1.2%	0.7	3.0%
Traffic Level within 200m						
Low	24	100.0%	21.9	91.2%	23.5	97.7%
Medium	0	0.0%	2.1	8.8%	0.5	2.3%
High	0	0.0%	0.0	0.0%	0.0	0.0%
Truck Route within 200m						
No Nearby Truck Route	3.2	13.4%	0.2	0.6%	1.4	5.6%
Nearby Truck Route	20.8	86.5%	23.8	99.4%	22.6	94.4%

Table B. Unique Trips by Destination Type

	Day 1					Day 2					Day 3				
Description	**Total**	**Walking**	**Biking**	**Transit**	**Vehicle**	**Total**	**Walking**	**Biking**	**Transit**	**Vehicle**	**Total**	**Walking**	**Biking**	**Transit**	**Vehicle**
Total	**7**	**0**	**0**	**0**	**7**	**7**	**2**	**0**	**0**	**5**	**6**	**0**	**0**	**0**	**6**
Home	**1**	0	0	0	1	**1**	0	0	0	1	**1**	0	0	0	1
Work	**0**	0	0	0	0	**0**	0	0	0	0	**0**	0	0	0	0
Education	**0**	0	0	0	0	**0**	0	0	0	0	**0**	0	0	0	0
Volunteer	**0**	0	0	0	0	**0**	0	0	0	0	**0**	0	0	0	0
Pickup-Dropoff	**2**	0	0	0	2	**0**	0	0	0	0	**2**	0	0	0	2
Dining/Eating	**2**	0	0	0	2	**1**	1	0	0	0	**1**	0	0	0	1
Shopping	**0**	0	0	0	0	**2**	0	0	0	2	**1**	0	0	0	1
Services	**1**	0	0	0	1	**3**	1	0	0	2	**1**	0	0	0	1
Recreational/Exercise	**0**	0	0	0	0	**0**	0	0	0	0	**0**	0	0	0	0
Residential Visit	**1**	0	0	0	1	**0**	0	0	0	0	**0**	0	0	0	0
Community/Public	**0**	0	0	0	0	**0**	0	0	0	0	**0**	0	0	0	0

Participant 316:

Profile: Male, Hispanic, between 21-39 years old, prefers Spanish, completed less than high school

Household Composition: No young children (<5), two older children (6-17), two adults (18-65), no seniors (>65)

Work and Transportation: Disabled or unable to work, one household car

Table A. Hours and Percent of Day by Microenvironment, Travel Mode and Proximity to Traffic and Truck Routes

	Day 1		Day 2		Day 3	
	Hours	%Time	Hours	%Time	Hours	%Time
Microenvironment						
Indoors	18.4	76.7%	20.4	85.1%	20.1	83.9%
Outdoors	4.1	17.1%	3.4	14.2%	3.6	15.2%
In-Vehicle	1.5	6.2%	0.2	0.6%	0.2	0.9%
Travel & Mode						
Not Traveling	22.5	93.5%	23.6	98.3%	23.3	97.2%
Walking	0.2	0.8%	0.2	1.0%	0.4	1.8%
Biking	0	0.0%	0.0	0.0%	0.0	0.0%
Transit Travel	0	0.0%	0.0	0.0%	0.0	0.0%
Vehicle Travel	1.4	5.6%	0.2	0.6%	0.2	0.9%
Traffic Level within 200m						
Low	23.3	97.0%	24.0	100.0%	24.0	100.0%
Medium	0.2	0.7%	0.0	0.0%	0.0	0.0%
High	0.6	2.3%	0.0	0.0%	0.0	0.0%
Truck Route within 200m						
No Nearby Truck Route	23.3	96.9%	24.0	100.0%	24.0	100.0%
Nearby Truck Route	0.7	3.1%	0.0	0.0%	0.0	0.0%

Table B. Unique Trips by Destination Type

	Day 1					Day 2					Day 3				
Description	**Total**	**Walking**	**Biking**	**Transit**	**Vehicle**	**Total**	**Walking**	**Biking**	**Transit**	**Vehicle**	**Total**	**Walking**	**Biking**	**Transit**	**Vehicle**
Total	**14**	**2**	**0**	**0**	**12**	**4**	**2**	**0**	**0**	**2**	**6**	**3**	**0**	**0**	**3**
Home	**4**	1	0	0	3	**2**	1	0	0	1	**2**	1	0	0	1
Work	**0**	0	0	0	0	**0**	0	0	0	0	**0**	0	0	0	0
Education	**0**	0	0	0	0	**0**	0	0	0	0	**0**	0	0	0	0
Volunteer	**0**	0	0	0	0	**0**	0	0	0	0	**0**	0	0	0	0
Pickup-Dropoff	**2**	1	0	0	1	**1**	1	0	0	0	**1**	1	0	0	0
Dining/Eating	**2**	0	0	0	2	**0**	0	0	0	0	**0**	0	0	0	0
Shopping/Retail	**1**	0	0	0	1	**0**	0	0	0	0	**1**	1	0	0	0
Services	**2**	0	0	0	2	**0**	0	0	0	0	**0**	0	0	0	0
Recreational/Exercise	**1**	0	0	0	1	**1**	0	0	0	1	**1**	0	0	0	1
Residential Visit	**2**	0	0	0	2	**0**	0	0	0	0	**1**	0	0	0	1
Community/Public	**0**	0	0	0	0	**0**	0	0	0	0	**0**	0	0	0	0

Participant 317:

Profile: Female, Hispanic, between 40-65 years old, prefers Spanish, completed less than high school

Household Composition: One young child (<5), one older children (6-17), two adults (18-65), no seniors (>65)

Work and Transportation: Works at home / homemaker, no household car

Table A. Hours and Percent of Day by Microenvironment, Travel Mode and Proximity to Traffic and Truck Routes

	Day 1		Day 2		Day 3	
	Hours	%Time	Hours	%Time	Hours	%Time
Microenvironment						
Indoors	21	87.6%	21.3	88.6%	22.5	93.8%
Outdoors	0.6	2.6%	2.4	10.0%	1.5	6.2%
In-Vehicle	2.4	9.8%	0.3	1.4%	0.0	0.0%
Travel & Mode						
Not Traveling	21.5	89.7%	22.4	93.4%	22.5	93.8%
Walking	0.2	0.7%	1.2	5.2%	1.5	6.2%
Biking	0	0.0%	0.0	0.0%	0.0	0.0%
Transit Travel	1.8	7.5%	0.3	1.4%	0.0	0.0%
Vehicle Travel	0.5	2.1%	0.0	0.0%	0.0	0.0%
Traffic Level within 200m						
Low	22.5	93.9%	23.4	97.5%	24.0	100.0%
Medium	1.5	6.1%	0.6	2.5%	0.0	0.0%
High	0	0.0%	0.0	0.0%	0.0	0.0%
Truck Route within 200m						
No Nearby Truck Route	23.6	98.5%	21.9	91.1%	24.0	100.0%
Nearby Truck Route	0.4	1.5%	2.1	8.9%	0.0	0.0%

Table B. Unique Trips by Destination Type

	Day 1					Day 2					Day 3				
Description	**Total**	**Walking**	**Biking**	**Transit**	**Vehicle**	**Total**	**Walking**	**Biking**	**Transit**	**Vehicle**	**Total**	**Walking**	**Biking**	**Transit**	**Vehicle**
Total	**7**	**2**	**0**	**3**	**2**	**15**	**11**	**0**	**4**	**0**	**4**	**4**	**0**	**0**	**0**
Home	**1**	0	0	0	1	**4**	3	0	1	0	**2**	2	0	0	0
Work	**0**	0	0	0	0	**0**	0	0	0	0	**0**	0	0	0	0
Education	**0**	0	0	0	0	**0**	0	0	0	0	**0**	0	0	0	0
Volunteer	**0**	0	0	0	0	**0**	0	0	0	0	**0**	0	0	0	0
Pickup-Dropoff	**0**	0	0	0	0	**0**	0	0	0	0	**0**	0	0	0	0
Dining/Eating	**0**	0	0	0	0	**3**	2	0	1	0	**0**	0	0	0	0
Shopping	**0**	0	0	0	0	**7**	5	0	2	0	**2**	2	0	0	0
Services	**0**	0	0	0	0	**1**	1	0	0	0	**0**	0	0	0	0
Recreational/Exercise	**0**	0	0	0	0	**0**	0	0	0	0	**0**	0	0	0	0
Residential Visit	**6**	2	0	3	1	**0**	0	0	0	0	**0**	0	0	0	0
Community/Public	**0**	0	0	0	0	**0**	0	0	0	0	**0**	0	0	0	0

Participant 318:

Profile: Female, Hispanic, between 21-39 years old, prefers Spanish, completed less than high school

Household Composition: One young child (<5), one older child (6-17), two adults (18-65), no seniors (>65)

Work and Transportation: Student without working / homemaker, one household car

Table A. Hours and Percent of Day by Microenvironment, Travel Mode and Proximity to Traffic and Truck Routes

	Day 1		Day 2		Day 3	
	Hours	%Time	Hours	%Time	Hours	%Time
Microenvironment						
Indoors	21.9	91.4%	22.8	95.2%	21.7	90.3%
Outdoors	0.6	2.7%	0.9	3.7%	1.0	4.0%
In-Vehicle	1.4	6.0%	0.3	1.1%	1.4	5.7%
Travel & Mode						
Not Traveling	22.4	93.2%	22.9	95.6%	22.6	94.4%
Walking	0.2	0.8%	0.8	3.4%	0.2	0.9%
Biking	0	0.0%	0.0	0.0%	0.0	0.0%
Transit Travel	0	0.0%	0.1	0.3%	0.0	0.0%
Vehicle Travel	1.4	6.0%	0.2	0.6%	1.1	4.8%
Traffic Level within 200m						
Low	22.8	95.2%	24.0	100.0%	23.4	97.5%
Medium	1	4.1%	0.0	0.0%	0.3	1.2%
High	0.2	0.7%	0.0	0.0%	0.3	1.3%
Truck Route within 200m						
No Nearby Truck Route	23.6	98.1%	23.9	99.4%	23.6	98.4%
Nearby Truck Route	0.4	1.9%	0.1	0.6%	0.4	1.6%

Table B. Unique Trips by Destination Type

	Day 1					Day 2					Day 3				
Description	**Total**	**Walking**	**Biking**	**Transit**	**Vehicle**	**Total**	**Walking**	**Biking**	**Transit**	**Vehicle**	**Total**	**Walking**	**Biking**	**Transit**	**Vehicle**
Total	**9**	**2**	**0**	**0**	**7**	**12**	**9**	**0**	**1**	**2**	**11**	**4**	**0**	**0**	**7**
Home	**2**	1	0	0	1	**5**	4	0	1	0	**4**	2	0	0	2
Work	**2**	0	0	0	2	**1**	0	0	0	1	**2**	0	0	0	2
Education	**1**	1	0	0	0	**1**	1	0	0	0	**0**	0	0	0	0
Volunteer	**0**	0	0	0	0	**0**	0	0	0	0	**0**	0	0	0	0
Pickup-Dropoff	**0**	0	0	0	0	**1**	1	0	0	0	**3**	1	0	0	2
Dining/Eating	**0**	0	0	0	0	**0**	0	0	0	0	**0**	0	0	0	0
Shopping/Retail	**0**	0	0	0	0	**2**	2	0	0	0	**1**	0	0	0	1
Services	**2**	0	0	0	2	**0**	0	0	0	0	**0**	0	0	0	0
Recreational/Exercise	**0**	0	0	0	0	**0**	0	0	0	0	**0**	0	0	0	0
Residential Visit	**2**	0	0	0	2	**2**	1	0	0	1	**1**	1	0	0	0
Community/Public	**0**	0	0	0	0	**0**	0	0	0	0	**0**	0	0	0	0

Participant 319:

Profile: Female, Hispanic, between 21-39 years old, prefers Spanish, completed less than high school

Household Composition: Two young children (<5), one older child (6-17), two adults (18-65), no seniors (>65)

Work and Transportation: Works at home / homemaker, two household cars

Table A. Hours and Percent of Day by Microenvironment, Travel Mode and Proximity to Traffic and Truck Routes

	Day 1		Day 2		Day 3	
	Hours	%Time	Hours	%Time	Hours	%Time
Microenvironment						
Indoors	22.1	92.0%	23.0	95.7%	20.6	85.7%
Outdoors	1.6	6.7%	1.0	4.3%	2.0	8.4%
In-Vehicle	0.3	1.3%	0.0	0.0%	1.4	5.8%
Travel & Mode						
Not Traveling	22.9	95.3%	23.3	96.9%	22.3	93.0%
Walking	0.9	3.5%	0.7	3.1%	0.3	1.4%
Biking	0	0.0%	0.0	0.0%	0.0	0.0%
Transit Travel	0	0.0%	0.0	0.0%	0.0	0.0%
Vehicle Travel	0.3	1.1%	0.0	0.0%	1.3	5.6%
Traffic Level within 200m						
Low	23.1	96.4%	22.2	92.6%	15.8	66.0%
Medium	0	0.0%	0.0	0.0%	7.8	32.7%
High	0.9	3.6%	1.8	7.4%	0.3	1.3%
Truck Route within 200m						
No Nearby Truck Route	18.8	78.2%	22.2	92.4%	16.1	67.0%
Nearby Truck Route	5.2	21.8%	1.8	7.6%	7.9	33.0%

Table B. Unique Trips by Destination Type

	Day 1					Day 2					Day 3				
Description	**Total**	**Walking**	**Biking**	**Transit**	**Vehicle**	**Total**	**Walking**	**Biking**	**Transit**	**Vehicle**	**Total**	**Walking**	**Biking**	**Transit**	**Vehicle**
Total	**17**	**13**	**0**	**0**	**4**	**8**	**8**	**0**	**0**	**0**	**11**	**4**	**0**	**0**	**7**
Home	**4**	3	0	0	1	**3**	3	0	0	0	**4**	2	0	0	2
Work	**0**	0	0	0	0	**0**	0	0	0	0	**0**	0	0	0	0
Education	**0**	0	0	0	0	**0**	0	0	0	0	**1**	1	0	0	0
Volunteer	**0**	0	0	0	0	**0**	0	0	0	0	**0**	0	0	0	0
Pickup-Dropoff	**3**	3	0	0	0	**4**	4	0	0	0	**2**	1	0	0	1
Dining/Eating	**0**	0	0	0	0	**0**	0	0	0	0	**0**	0	0	0	0
Shopping/Retail	**4**	3	0	0	1	**0**	0	0	0	0	**0**	0	0	0	0
Services	**1**	0	0	0	1	**0**	0	0	0	0	**0**	0	0	0	0
Recreational/Exercise	**0**	0	0	0	0	**0**	0	0	0	0	**0**	0	0	0	0
Residential Visit	**5**	4	0	0	1	**1**	1	0	0	0	**3**	0	0	0	3
Community/Public	**0**	0	0	0	0	**0**	0	0	0	0	**1**	0	0	0	1

Participant 320:

Profile: Female, Hispanic, between 21-39 years old, prefers Spanish, completed less than high school

Household Composition: One young child (<5), four older children (6-17), two adults (18-65), no seniors (>65)

Work and Transportation: Works at home / homemaker, two household cars

Table A. Hours and Percent of Day by Microenvironment, Travel Mode and Proximity to Traffic and Truck Routes

	Day 1		Day 2		Day 3	
	Hours	%Time	Hours	%Time	Hours	%Time
Microenvironment						
Indoors	21.5	89.6%	24.0	100.0%	23.4	97.3%
Outdoors	2.1	8.9%	0.0	0.0%	0.1	0.5%
In-Vehicle	0.3	1.4%	0.0	0.0%	0.5	2.2%
Travel & Mode						
Not Traveling	23.8	99.1%	24.0	100.0%	23.7	98.8%
Walking	0	0.2%	0.0	0.0%	0.0	0.0%
Biking	0	0.0%	0.0	0.0%	0.0	0.0%
Transit Travel	0	0.0%	0.0	0.0%	0.0	0.0%
Vehicle Travel	0.2	0.7%	0.0	0.0%	0.3	1.2%
Traffic Level within 200m						
Low	24	100.0%	24.0	100.0%	24.0	99.8%
Medium	0	0.0%	0.0	0.0%	0.0	0.2%
High	0	0.0%	0.0	0.0%	0.0	0.0%
Truck Route within 200m						
No Nearby Truck Route	23.5	98.1%	24.0	100.0%	23.8	99.2%
Nearby Truck Route	0.5	1.9%	0.0	0.0%	0.2	0.8%

Table B. Unique Trips by Destination Type

	Day 1					Day 2					Day 3				
Description	**Total**	**Walking**	**Biking**	**Transit**	**Vehicle**	**Total**	**Walking**	**Biking**	**Transit**	**Vehicle**	**Total**	**Walking**	**Biking**	**Transit**	**Vehicle**
Total	**6**	**2**	**0**	**0**	**4**	**0**	**0**	**0**	**0**	**0**	**3**	**0**	**0**	**0**	**3**
Home	**1**	0	0	0	1	**0**	0	0	0	0	**1**	0	0	0	1
Work	**0**	0	0	0	0	**0**	0	0	0	0	**0**	0	0	0	0
Education	**0**	0	0	0	0	**0**	0	0	0	0	**0**	0	0	0	0
Volunteer	**0**	0	0	0	0	**0**	0	0	0	0	**0**	0	0	0	0
Pickup-Dropoff	**0**	0	0	0	0	**0**	0	0	0	0	**1**	0	0	0	1
Dining/Eating	**0**	0	0	0	0	**0**	0	0	0	0	**0**	0	0	0	0
Shopping	**1**	0	0	0	1	**0**	0	0	0	0	**0**	0	0	0	0
Services	**0**	0	0	0	0	**0**	0	0	0	0	**0**	0	0	0	0
Recreational/Exercise	**0**	0	0	0	0	**0**	0	0	0	0	**0**	0	0	0	0
Residential Visit	**4**	2	0	0	2	**0**	0	0	0	0	**1**	0	0	0	1
Community/Public	**0**	0	0	0	0	**0**	0	0	0	0	**0**	0	0	0	0

Participant 321:

Profile: Female, Non-Hispanic, between 21-39 years old, prefers English, completed B.A. or higher

Household Composition: No young child (<5), no older children (6-17), three adults (18-65), no seniors (>65)

Work and Transportation: Student and working, three household cars

Table A. Hours and Percent of Day by Microenvironment, Travel Mode and Proximity to Traffic and Truck Routes

	Day 1		Day 2		Day 3	
	Hours	%Time	Hours	%Time	Hours	%Time
Microenvironment						
Indoors	23.3	97.1%	20.2	84.0%	20.3	84.6%
Outdoors	0	0.0%	0.3	1.3%	1.4	6.0%
In-Vehicle	0.7	2.9%	3.5	14.7%	2.3	9.4%
Travel & Mode						
Not Traveling	23.3	97.1%	21.0	87.3%	22.0	91.7%
Walking	0	0.0%	0.0	0.0%	0.3	1.3%
Biking	0	0.0%	0.0	0.0%	0.0	0.0%
Transit Travel	0	0.0%	0.0	0.0%	0.0	0.0%
Vehicle Travel	0.7	2.9%	3.0	12.7%	1.7	7.0%
Traffic Level within 200m						
Low	20.6	85.9%	23.2	96.5%	18.2	75.7%
Medium	3.4	14.1%	0.8	3.5%	5.8	24.3%
High	0	0.0%	0.0	0.0%	0.0	0.0%
Truck Route within 200m						
No Nearby Truck Route	23.7	98.9%	23.6	98.2%	23.5	98.0%
Nearby Truck Route	0.3	1.1%	0.4	1.8%	0.5	2.0%

Table B. Unique Trips by Destination Type

	Day 1					Day 2					Day 3				
Description	**Total**	**Walking**	**Biking**	**Transit**	**Vehicle**	**Total**	**Walking**	**Biking**	**Transit**	**Vehicle**	**Total**	**Walking**	**Biking**	**Transit**	**Vehicle**
Total	**2**	**0**	**0**	**0**	**2**	**8**	**0**	**0**	**0**	**8**	**9**	**3**	**0**	**0**	**6**
Home	**1**	0	0	0	1	**1**	0	0	0	1	**1**	0	0	0	1
Work	**1**	0	0	0	1	**1**	0	0	0	1	**1**	0	0	0	1
Education	**0**	0	0	0	0	**0**	0	0	0	0	**2**	1	0	0	1
Volunteer	**0**	0	0	0	0	**0**	0	0	0	0	**0**	0	0	0	0
Pickup-Dropoff	**0**	0	0	0	0	**3**	0	0	0	3	**0**	0	0	0	0
Dining/Eating	**0**	0	0	0	0	**1**	0	0	0	1	**1**	0	0	0	1
Shopping	**0**	0	0	0	0	**1**	0	0	0	1	**1**	0	0	0	1
Services	**0**	0	0	0	0	**0**	0	0	0	0	**3**	2	0	0	1
Recreational/Exercise	**0**	0	0	0	0	**0**	0	0	0	0	**0**	0	0	0	0
Residential Visit	**0**	0	0	0	0	**1**	0	0	0	1	**0**	0	0	0	0
Community/Public	**0**	0	0	0	0	**0**	0	0	0	0	**0**	0	0	0	0

Participant 322:

Profile: Female, Hispanic, between 21-39 years old, prefers Spanish, completed high school

Household Composition: One young child (<5), no older children (6-17), three adults (18-65), no seniors (>65)

Work and Transportation: Works at home / homemaker, two household cars

Table A. Hours and Percent of Day by Microenvironment, Travel Mode and Proximity to Traffic and Truck Routes

	Day 1		Day 2		Day 3	
	Hours	%Time	Hours	%Time	Hours	%Time
Microenvironment						
Indoors	23.7	99.0%	22.7	94.6%	18.9	78.7%
Outdoors	0.3	1.0%	1.2	4.9%	3.4	14.2%
In-Vehicle	0	0.0%	0.1	0.5%	1.7	7.2%
Travel & Mode						
Not Traveling	23.7	99.0%	22.9	95.4%	22.7	94.5%
Walking	0.3	1.0%	1.0	4.2%	0.3	1.4%
Biking	0	0.0%	0.0	0.0%	0.0	0.0%
Transit Travel	0	0.0%	0.0	0.0%	0.0	0.0%
Vehicle Travel	0	0.0%	0.1	0.3%	1.0	4.0%
Traffic Level within 200m						
Low	24	100.0%	24.0	100.0%	23.5	97.8%
Medium	0	0.0%	0.0	0.0%	0.5	2.2%
High	0	0.0%	0.0	0.0%	0.0	0.0%
Truck Route within 200m						
No Nearby Truck Route	0	0.1%	0.6	2.4%	2.6	10.7%
Nearby Truck Route	24	99.9%	23.4	97.6%	21.4	89.3%

Table B. Unique Trips by Destination Type

	Day 1					Day 2					Day 3				
Description	**Total**	**Walking**	**Biking**	**Transit**	**Vehicle**	**Total**	**Walking**	**Biking**	**Transit**	**Vehicle**	**Total**	**Walking**	**Biking**	**Transit**	**Vehicle**
Total	**4**	**4**	**0**	**0**	**0**	**7**	**6**	**0**	**0**	**1**	**11**	**6**	**0**	**0**	**5**
Home	**1**	1	0	0	0	3	2	0	0	1	4	3	0	0	1
Work	**0**	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Education	**0**	0	0	0	0	0	0	0	0	0	2	2	0	0	0
Volunteer	**0**	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pickup-Dropoff	**2**	2	0	0	0	2	2	0	0	0	1	1	0	0	0
Dining/Eating	**0**	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Shopping	**0**	0	0	0	0	2	2	0	0	0	0	0	0	0	0
Services	**0**	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Recreational/Exercise	**0**	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Residential Visit	**1**	1	0	0	0	0	0	0	0	0	4	0	0	0	4
Community/Public	**0**	0	0	0	0	0	0	0	0	0	0	0	0	0	0

11.2 In-Home Particle Number Concentrations (Particles / cm^{-3})

	201 2nd floor unit in 2 story Apt Bldg		202 1st floor unit in 2 story Apt Bldg		203 1st floor unit in 3 story Apt Bldg		204 1 story single-family house, central air	
	Baseline 14:30 start, 2/21 Open doors/windows Potential Source: WH	*Followup* 12:45 start, 3/25 Open doors/windows Potential Source: WH	*Baseline* 13:15 start, 2/25 Open doors/windows Potential Source: CK	*Followup* 16:45 start, 3/7 Open doors/windows Potential Source: HACT	*Baseline* 17:30 start, 2/25 Open doors/windows Potential Source: WH CPC Status: LOALC	*Followup* 21:15 start, 4/1 Open doors/windows Potential Source: WH	*Baseline* 10:45 start, 2/28 Closed doors/windows Potential Source: TRP CPC Status: Save Problem	*Followup* 14:00 start, 3/26 Open doors/windows Potential Source: TRP
Minutes	22	16	16	26	16	14	No data	17
Mean	*13,100*	*29,500*	*27,500*	*27,800*	*43,700*	*43,100*		*43,400*
Max	25,200	33,800	28,500	35,300	54,800	46,800		58,000
Min	6,100	26,600	26,800	22,000	16,700	38,900		35,100
Median	12,000	29,400	27,400	27,700	51,500	43,200		41,300
SD	5,200	2,000	500	4,200	14,900	2,600		6,400

	205 2nd floor unit in 2 story Apt Bldg		206 Small 1-story old wood building		207 Top story of 4-story Apt Bldg		208 1 story single-family house, central air	
	Baseline 13:15 start, 2/21 Open doors/windows Potential Source: WH, TRP	*Followup* 12:45 start, 3/17 Open doors/windows	*Baseline* 14:45 start, 2/25 Open doors/windows	*Followup* 14:00 start, 4/9 Open doors/windows	*Baseline* 16:00 start, 2/25 Open doors/windows Potential Source: TRP	*Followup* 13:15 start, 4/9 Open doors/windows	*Baseline* 18:15 start, 2/25 Closed doors/windows & heat Potential Source: CK, WH	*Followup* 16:15 start, 4/21 Open doors/windows
Minutes	23	25	44	43	16	33	58	19
Mean	*13,400*	*25,000*	*24,400*	*23,500*	*64,600*	*29,300*	*26,300*	*26,600*
Max	16,500	28,400	27,300	28,500	76,800	56,800	31,800	37,700
Min	8,500	22,700	22,700	18,700	57,800	19,300	22,000	19,500
Median	14,600	25,100	24,400	23,400	62,300	26,300	26,400	25,200
SD	2,500	1,500	1,200	2,100	5,600	8,800	2,900	6,700

	209 2nd floor unit in 2 story Apt Bldg		210 1st&2nd floor unit in 2 story Apt Bldg		211 Small 1-story old wood building		212 1 story single-family house	
	Baseline 13:00 start, 2/26 Open doors/windows Potential Source: CLN	*Followup* 14:45 start, 4/17 Open doors/windows Potential Source: CLN	*Baseline* 11:00 start, 3/3 Open doors/windows Potential Source: FAN	*Followup* 10:15 start, 4/15 Open doors/windows Potential Source: CK, FAN	*Baseline* 13:45 start, 3/3 Open doors/windows	*Followup* CPC Status: Maintenance	*Baseline* 12:15 start, 3/4 Open doors/windows Potential Source: CK	*Followup* 15:45 start, 4/22 Open doors/windows Potential Source: CK, CLN
Minutes	36	16	62	26	53	No data	44	15
Mean	*20,800*	*37,600*	*23,700*	*6,100*	*19,500*		*31,700*	*50,000*
Max	24,500	42,600	28,000	7,900	28,700		40,600	56,600
Min	17,800	33,700	21,000	4,500	15,500		26,500	44,400
Median	21,200	37,400	23,600	6,000	18,100		30,100	49,100
SD	1,900	3,000	1,600	1,100	3,000		4,000	4,000

	213 1 story single-family house, back bldg		214 2nd floor unit in 2 story Apt Bldg		215 1 story wide mobile home		216 2nd floor unit in 2 story Apt Bldg	
	Baseline 17:45 start, 3/10 Open doors/windows	*Followup* 16:30 start, 4/22 Open doors/windows Potential Source: CLN	*Baseline* 13:45 start, 3/4 Open doors/windows	*Followup* 14:15 start, 4/22 Open doors/windows Potential Source: CK CPC Status: Maintenance	*Baseline* 10:00 start, 3/24 Closed doors/windows & AC	*Followup* 18:15 start, 5/3 Open doors/windows	*Baseline* 11:15 start, 3/25 Open doors/windows	*Followup* 16:45 start, 5/20 Open doors/windows
Minutes	15	18	40	20	48	15	34	14
Mean	*52,500*	*30,600*	*17,700*	*143,600*	*13,600*	*16,600*	*34,700*	*8,800*
Max	65,300	31,600	19,300	181,000	20,500	22,900	44,000	9,400
Min	43,700	29,200	15,800	110,600	11,400	12,800	29,000	8,300
Median	52,000	30,600	17,400	140,400	13,400	16,800	34,600	8,800
SD	6,200	700	900	22,600	1,800	2,800	4,400	300

	217 1st floor unit in 2 story Apt Bldg		218 3rd floor unit in 3 story Apt Bldg		219 3rd floor unit in steel high rise apts		220 1st floor unit in old 1-story Apt Bldg	
	Baseline 16:30 start, 3/10 Open doors/windows & AC	*Followup* 14:15 start, 5/12 Open doors/windows Potential Source: CK	*Baseline* 20:15 start, 4/7 Open doors/windows	*Followup* CPC Status: Maintenance	*Baseline* 19:00 start, 4/1 Closed doors/windows Potential Source: TRP	*Followup* 18:30 start, 5/21 Open doors/windows Potential Source: CK, TRP	*Baseline* 13:15 start, 4/7 Open doors/windows Potential Source: CK CPC Status: LOALC	*Followup* 15:15 start, 5/20 Open doors/windows
Minutes	37	20	29	No data	32	15	33	15
Mean	*34,200*	*42,200*	*25,600*		*5,900*	*37,700*	*45,200*	*16,100*
Max	43,100	64,600	29,400		6,100	43,500	170,700	21,300
Min	25,300	30,500	20,000		5,700	32,400	12,200	7,300
Median	33,500	41,000	26,100		5,900	37,600	13,600	17,100
SD	6,100	8,500	3,600		100	3,600	57,300	4,200

	221 3stories of new 3-story Apt Bldg		222 2nd story room in hotel		223 Back room of 1-story barbershop		224 1 story single familyhouse (large)	
	Baseline 13:30 start, 4/28 Open doors/windows	*Followup* CPC Status: Maintenance	*Baseline* 9:15 start, 4/17 Open doors/windows Potential Source: SMK	*Followup*	*Baseline* 17:00 start, 5/1 Open doors/windows	*Followup* 16:30 start, 6/17 Open doors/windows	*Baseline* 18:00 start, 4/21 Open doors/windows Potential Source: CK	*Followup* 16:45 start, 6/11 Open doors/windows
Minutes	26	No data	31	No data	29	15	38	17
Mean	*7,200*		*62,200*		*18,600*	*20,500*	*45,100*	*16,700*
Max	8,100		84,400		28,000	22,300	53,800	19,300
Min	6,500		49,400		16,500	16,800	34,900	12,900
Median	7,200		55,400		17,400	20,600	47,400	16,600
SD	500		12,200		2,600	1,600	6,200	1,700

	225 2nd floor unit in 3 story Apt Bldg		226 1 story wood building on multi-BLDG lot		227 (3 Baseline Monitoring Locations) 3stories of new 3-story Apt Bldg			
	Baseline 11:15 start, 5/12 Open doors/windows Potential Source: SMK	*Followup* 11:15 start, 6/5 Open doors/windows	*Baseline* 12:30 start, 5/2 Open doors/windows	*Followup* 13:15 start, 6/30 Open doors/windows	*Baseline 2nd floor* 14:15 start, 4/28 Open doors/windows	*Baseline 3rd floor* 14:32 start, 4/28 Open doors/windows	*Baseline 2nd floor* 14:48 start, 4/28 Open doors/windows	*Followup*
Minutes	28	14	27	18	18	15	9	No data
Mean	*37,500*	*20,000*	*22,900*	*8,900*	*78,700*	*15,000*	*21,600*	
Max	63,800	27,100	32,500	10,400	107,400	22,400	24,200	
Min	31,900	16,100	16,300	7,400	25,400	10,800	20,300	
Median	35,700	19,200	20,300	8,900	83,500	13,900	21,900	
SD	6,000	3,100	5,800	900	22,800	4,000	1,200	

	228 Trailer		300 2nd floor unit in 3 story Apt Bldg		301 1st floor unit in 2 story Apt Bldg		302 1st floor in 1-story duplex	
	Baseline 19:15 start, 4/21 Open doors/windows CPC Status: Maintenance	*Followup* CPC Status: Maintenance	*Baseline* 16:00 start, 5/5 Open doors/windows	*Followup* 12:20 start, 6/5 Open doors/windows Potential Source: CLN	*Baseline* 14:45 start, 5/5 Open doors/windows Potential Source: CK	*Followup* 10:20 start, 6/30 Open doors/windows	*Baseline* 13:00 start, 5/5 Open doors/windows	*Followup* 10:00 start, 6/5 Open doors/windows Potential Source: CK
Minutes	43	No data	43	16	34	16	32	16
Mean	*12,900*		*16,800*	*20,900*	*20,400*	*36,800*	*13,700*	*12,900*
Max	14,600		27,700	22,900	31,600	40,100	23,500	15,600
Min	11,400		10,700	18,300	15,100	34,000	8,600	10,400
Median	12,600		15,900	21,100	19,400	36,400	12,700	12,800
SD	1,000		4,500	1,300	4,300	2,000	4,100	1,500

	303 3stories of new 3-story Apt Bldg		304 1-story single family home		305 2nd story of 3-story Apt Bldg		306 2nd story of 3-story Apt Bldg	
	Baseline 10:15 start, 5/5 Open doors/windows Potential Source: CK CPC Status: LOALC	*Followup* 16:15 start, 6/11 Open doors/windows	*Baseline* 12:00 start, 5/12 Open doors/windows	*Followup* 17:00 start, 6/17 Open doors/windows & AC Potential Source: HACT	*Baseline* 17:30 start, 5/6 Open doors/windows	*Followup* 16:00 start, 6:10 Open doors/windows Potential Source: CLN	*Baseline* 13:30 start, 5/12 Open doors/windows Potential Source: CK	*Followup* 18:40 start, 6/30 Open doors/windows
Minutes	37	14	28	17	33	15	19	14
Mean	*23,100*	*15,300*	*16,000*	*52,600*	*6,300*	*15,000*	*21,000*	*24,700*
Max	35,100	15,600	20,000	57,800	11,600	18,400	28,000	26,400
Min	12,500	14,900	13,300	49,800	3,200	11,200	16,000	23,700
Median	23,500	15,200	15,800	52,100	5,700	15,100	20,500	24,500
SD	6,900	200	1,500	2,500	2,200	1,900	3,900	800

	307 2nd story of 3-story Apt Bldg		308 1st floor in 1-story duplex		309 1st floor in 1-story duplex		310 1st floor in 1bldg on multihouse	
	Baseline 16:15 start, 5/15 Open doors/windows Potential Source: CK, WH	*Followup* 16:00 start, 6/19 Open doors/windows Potential Source: CK, WH	*Baseline* 11:30 start, 5/13 Open doors/windows Potential Source: CK, HACT	*Followup* 13:30 start, 6/19 Open doors/windows Potential Source: CK CPC Status: Low Batteries	*Baseline* 13:15 start, 5/13 Open doors/windows	*Followup* 12:00 start, 6/10 Open doors/windows Potential Source: CK	*Baseline* 16:00 start, 5/15 Open doors/windows	*Followup* 16:00 start, 6/19 Open doors/windows
Minutes	45	16	31	9	38	15	36	15
Mean	*11,100*	*56,900*	*28,700*	*44,400*	*66,400*	*21,800*	*15,600*	*37,800*
Max	17,900	94,100	36,400	46,600	118,800	33,000	25,700	42,100
Min	8,100	31,100	24,300	42,300	38,300	15,400	8,700	30,900
Median	10,400	52,900	28,200	44,300	59,900	20,000	16,100	39,600
SD	2,400	22,500	3,000	1,300	21,800	5,000	3,700	4,000

	311 1st floor unit in 3 story Apt Bldg		312 3stories of new 3-story Apt Bldg		313 3nd story of 3-story Apt Bldg		314 2nd story of 2-story Apt Bldg	
	Baseline 13:15 start, 5/15 Open doors/windows	*Followup* 13:00 start, 6/19 Open doors/windows	*Baseline* 19:15 start, 5/21 Closed doors/windows	*Followup* 13:30 start, 6/30 Open doors/windows	*Baseline* 1:15 start, 5/20 Open doors/windows Potential Source: WH	*Followup* 3:30 start, 6/24 Open doors/windows Potential Source: WH	*Baseline* 14:43 start, 5/27 Open doors/windows CPC Status: LOALC	*Followup* 14:30 start, 6/24 Open doors/windows Potential Source: FAN
Minutes	38	15	35	15	32	14	24	22
Mean	*46,300*	*30,500*	*14,000*	*33,500*	*11,200*	*19,100*	*7,100*	*21,000*
Max	54,600	34,600	14,900	34,800	15,400	20,500	9,400	22,000
Min	41,800	25,200	13,400	31,000	5,900	17,800	4,900	19,600
Median	46,200	31,800	14,000	33,500	12,800	19,200	7,000	21,100
SD	2,600	3,300	300	1,100	3,400	800	1,400	700

	315 3rd story of 3-story Apt Bldg		316 3rd story of 3-story Apt Bldg		317 1st story of 2-story Apt Bldg		318 1st floor in 1-story duplex	
	Baseline 15:00 start, 5/15 Open doors/windows Potential Source: WH, HACT	*Followup* 12:00 start, 6/24 Open doors/windows Potential Src: CK, HACT, WH	*Baseline* 13:20 start, 5/27 Open doors/windows Potential Source: WH CPC Status: LOALC	*Followup* 12:30 start, 6/24 Open doors/windows Potential Source: FAN	*Baseline* 15:30 start, 5/27 Open doors/windows CPC Status: LOALC	*Followup* 14:15 start, 6/24 Open doors/windows Potential Source: CK	*Baseline* 18:00 start, 5/27 Open doors/windows CPC Status: LOALC	*Followup* 15:30 start, 6/30 Open doors/windows
Minutes	28	19	30	14	28	15	25	21
Mean	*21,300*	*58,500*	*7,500*	*23,100*	*6,300*	*21,200*	*15,800*	*9,300*
Max	26,500	119,000	8,800	33,300	7,200	23,400	17,800	11,900
Min	16,500	25,100	5,000	17,800	4,500	19,500	11,800	7,600
Median	21,600	51,900	7,700	21,800	6,300	21,200	16,500	9,300
SD	3,300	26,600	900	4,100	700	1,200	1,700	1,100

	319 3stories of new 3-story Apt Bldg		320 3stories of new 3-story Apt Bldg		321 2nd floor of 2-story Apt Bldg		322 2nd floor of 2-story Apt Bldg	
	Baseline 13:30 start, 6/5 Open doors/windows	*Followup* 12:15 start, 6/30 Open doors/windows	*Baseline*	*Followup* 16:00 start, 6/30 Open doors/windows	*Baseline* 14:30 start, 6/5 Open doors/windows	*Followup* 17:30 start, 6/30 Open doors/windows	*Baseline* 13:45 start, 6/10 Open doors/windows	*Followup* 11:00 start, 6/30 Open doors/windows
Minutes	34	21	No data	15	26	14	50	16
Mean	*27,300*	*12,100*		*13,500*	*32,600*	*39,400*	*15,100*	*26,400*
Max	32,200	13,700		14,300	36,400	41,100	20,200	30,100
Min	22,800	10,900		11,600	28,500	37,500	9,400	22,200
Median	27,600	12,200		13,600	32,300	39,100	14,900	27,100
SD	2,800	700		700	2,400	1,200	2,600	3,000

NOTE: "Open doors/windows" indicates at least one was open/cracked, "Closed doors/windows" indicates all were closed during monitoring, LOALC= CPC "low alcohol" warning, CK=visible or recent stove or microwave cooking, CLN=smell of cleaning or cosmetic products, FAN= active ceiling, window or floor fan, HACT=human activity including walking/playing near instrument or recent construction in/near unit, SMK=smell of recent smoking, TRP=traffic proximity (approximate), WH=indoor water heater

11.3 In-Home Particle Mass Measurements ($\mu g\ m^{-3}$)

	201 2nd floor unit in 2 story Apt Bldg				202 1st floor unit in 2 story Apt Bldg			
	Baseline 14:30 start, 2/21 Open doors/windows Potential Source: WH		*Followup* 12:45 start, 3/25 Open doors/windows Potential Source: WH		*Baseline* 13:15 start, 2/25 Open doors/windows Potential Source: CK		*Followup* 16:45 start, 3/7 Open doors/windows Potential Source: HACT	
	Unit #1	*Unit #2*	*Unit #1*	*Unit #2*	*Unit #1*	*Unit #2*	*Unit #1*	*Unit #2*
Minutes	28	25	18	18	25	No data	31	34
Average	14.5	6.7	56.9	62.2	30.5		52.90	43.6
Max	19.0	11.0	97.0	70.0	33.0		62.00	62.0
Min	13.0	5.0	45.0	55.0	27.0		42.00	31.0
Median	14.0	6.0	50.5	62.0	31.0		55.00	45.0
SD	1.5	1.5	14.1	4.0	1.6		6.20	7.2

	203 1st floor unit in 3 story Apt Bldg				204 1 story single-family house, central air			
	Baseline 17:30 start, 2/25 Open doors/windows Potential Source: WH		*Followup* 21:15 start, 4/1 Open doors/windows Potential Source: WH		*Baseline* 10:45 start, 2/28 Closed doors/windows Potential Source: TRP		*Followup* 14:00 start, 3/26 Open doors/windows Potential Source: TRP	
	Unit #1	*Unit #2*	*Unit #1*	*Unit #2*	*Unit #1*	*Unit #2*	*Unit #1*	*Unit #2*
Minutes	No data	20	14	15	17	19	14	12
Average		15.5	31.9	38.5	20.2	7.6	43.8	49.3
Max		22.0	35.0	48.0	21.0	14.0	55.0	54.0
Min		11.0	30.0	32.0	19.0	6.0	36.0	45.0
Median		16.0	31.0	39.0	20.0	7.0	43.0	49.0
SD		2.7	2.0	4.4	0.7	2.2	5.7	2.6

	205 2nd floor unit in 2 story Apt Bldg				206 Small 1-story old wood building			
	Baseline 13:15 start, 2/21 Open doors/windows Potential Source: WH, TRP		*Followup* 12:45 start, 3/17 Open doors/windows Potential Source: WH, TRP		*Baseline* 14:45 start, 2/25 Open doors/windows		*Followup* 14:00 start, 4/9 Open doors/windows	
	Unit #1	*Unit #2*	*Unit #1*	*Unit #2*	*Unit #1*	*Unit #2*	*Unit #1*	*Unit #2*
Minutes	37	24	37	31	54	No data	40	43
Average	16.3	8.6	16.4	20.2	26.2		9.9	14.2
Max	18.0	58.0	23.0	36.0	29.0		13.0	28.0
Min	14.0	4.0	9.0	13.0	20.0		8.0	12.0
Median	16.0	6.0	16.0	20.0	26.0		9.5	13.0
SD	1.0	10.7	3.0	4.8	1.4		1.2	2.9

	207 Top story of 4-story Apt Bldg				208 1 story single-family house, central air			
	Baseline 16:00 start, 2/25 Open doors/windows Potential Source: TRP		*Followup* 13:15 start, 4/9 Open doors/windows Potential Source: TRP		*Baseline* 18:15 start, 2/25 Closed doors/windows & heat Potential Source: CK, WH		*Followup* 16:15 start, 4/21 Open doors/windows Potential Source: WH	
	Unit #1	*Unit #2*	*Unit #1*	*Unit #2*	*Unit #1*	*Unit #2*	*Unit #1*	*Unit #2*
Minutes	21	19	39	40	No data	65	24	25
Average	25.9	19.9	14.4	27.1		24.0	21.5	27.8
Max	28.0	64.0	27.0	62.0		60.0	24.0	33.0
Min	23.0	13.0	9.0	15.0		5.0	20.0	25.0
Median	26.0	17.0	13.0	25.5		24.0	21.5	27.0
SD	1.3	11.0	4.4	10.4		14.9	1.1	2.0

	209 2nd floor unit in 2 story Apt Bldg				210 1st&2nd floor unit in 2 story Apt Bldg			
	Baseline 13:00 start, 2/26 Open doors/windows Potential Source: CLN		*Followup* 14:45 start, 4/17 Open doors/windows Potential Source: CLN		*Baseline* 11:00 start, 3/3 Open doors/windows Potential Source: FAN		*Followup* 10:15 start, 4/15 Open doors/windows Potential Source: CK, FAN	
	Unit #1	*Unit #2*	*Unit #1*	*Unit #2*	*Unit #1*	*Unit #2*	*Unit #1*	*Unit #2*
Minutes	27	No data	22	19	51	56	33	33
Average	3.2		17.4	22.1	18.61	12.6	18.7	22.6
Max	5.0		28.0	36.0	25.00	21.0	20.0	25.0
Min	3.0		15.0	18.0	15.00	8.0	18.0	20.0
Median	3.0		17.0	21.0	17.00	11.0	19.0	23.0
SD	0.5		3.1	4.7	3.36	3.8	0.6	1.2

	211 Small 1-story old wood building				212 1 story single-family house			
	Baseline 13:45 start, 3/3 Open doors/windows		*Followup* 11:45 start, 6/2 Open doors/windows		*Baseline* 12:15 start, 3/4 Open doors/windows Potential Source: CK		*Followup* 15:45 start, 4/22 Open doors/windows Potential Source: CK, CLN	
	Unit #1	*Unit #2*	*Unit #1*	*Unit #2*	*Unit #1*	*Unit #2*	*Unit #1*	*Unit #2*
Minutes	25	30	15	16	45	48	21	24
Average	8.6	1.30	20.0	27.4	27.8	23.1	46.5	37.2
Max	15.0	23.00	21.0	31.0	48.0	56.0	410.0	50.0
Min	8.0	(1.00)	19.0	26.0	24.0	13.0	25.0	29.0
Median	8.0	-	20.0	27.0	26.0	20.0	29.0	37.0
SD	1.4	4.43	0.7	1.5	5.3	10.3	83.3	3.8

	213 1 story single-family house, back bldg				214 2nd floor unit in 2 story Apt Bldg			
	Baseline 17:45 start, 3/10 Open doors/windows		*Followup* 16:30 start, 4/22 Closed doors/windows Potential Source: CLN		*Baseline* 13:45 start, 3/4 Open doors/windows		*Followup* 14:15 start, 4/22 Open doors/windows Potential Source: CK	
	Unit #1	*Unit #2*	*Unit #1*	*Unit #2*	*Unit #1*	*Unit #2*	*Unit #1*	*Unit #2*
Minutes	19	18	18	20	48	47	21	21
Average	104.8	81.7	42.8	54.55	12.7	3.6	141.3	133.0
Max	133.0	110.0	46.0	76.00	16.0	8.0	250.0	262.0
Min	74.0	54.0	39.0	47.00	12.0	2.0	34.0	36.0
Median	105.0	83.0	43.0	53.50	13.0	3.0	141.0	144.0
SD	20.4	12.8	1.9	6.50	0.8	1.5	58.8	77.9

	215 1 story wide mobile home				216 2nd floor unit in 2 story Apt Bldg			
	Baseline 10:00 start, 3/24 Open doors/windows & AC		*Followup* 18:15 start, 5/3 Open doors/windows		*Baseline* 11:15 start, 3/25 Open doors/windows		*Followup* 16:45 start, 5/20 Open doors/windows	
	Unit #1	*Unit #2*	*Unit #1*	*Unit #2*	*Unit #1*	*Unit #2*	*Unit #1*	*Unit #2*
Minutes	37	40	21	21	38	39	19	21
Average	18.1	20.2	18.9	24.6	51.0	55.7	33.7	37.1
Max	34.0	26.0	27.0	27.0	63.0	73.0	35.0	39.0
Min	16.0	19.0	17.0	23.0	47.0	51.0	33.0	36.0
Median	17.0	20.0	18.0	24.0	49.0	55.0	34.0	37.0
SD	3.4	1.4	2.1	1.2	4.4	4.1	0.7	1.2

	217 1st floor unit in 2 story Apt Bldg				218 3rd floor unit in 3 story Apt Bldg			
	Baseline 16:30 start, 3/10 Open doors/windows & AC		*Followup* 14:15 start, 5/12 Open doors/windows Potential Source: CK		*Baseline* 20:15 start, 4/7 Open doors/windows		*Followup* 15:00 start, 6/2 Open doors/windows	
	Unit #1	*Unit #2*	*Unit #1*	*Unit #2*	*Unit #1*	*Unit #2*	*Unit #1*	*Unit #2*
Minutes	54	53	26	No data	35	33	15	15
Average	13.7	25.0	33.7		45.9	47.7	28.7	35.4
Max	19.0	311.0	47.0		65.0	59.0	30.0	42.0
Min	11.0	13.0	28.0		44.0	45.0	28.0	34.0
Median	13.5	17.0	32.0		45.0	47.0	29.0	35.0
SD	1.6	40.7	5.3		3.4	2.6	0.8	2.4

	219 3rd floor unit in steel high rise apts				220 1st floor unit in old 1-story Apt Bldg			
	Baseline 19:00 start, 4/1; Closed doors/windows; Potential Source: TRP		*Followup* 18:30 start, 5/21; Open doors/windows; Potential Source: CK, TRP		*Baseline* 13:15 start, 4/7; Open doors/windows; Potential Source: CK		*Followup* 15:15 start, 5/20; Open doors/windows	
	Unit #1	*Unit #2*	*Unit #1*	*Unit #2*	*Unit #1*	*Unit #2*	*Unit #1*	*Unit #2*
Minutes	39	39	16	14	40	39	22	21
Average	17.4	21.2	18.9	36.4	202.3	57.1	26.6	36.0
Max	20.0	28.0	28.0	145.0	2,107.0	804.0	28.0	127.0
Min	16.0	19.0	15.0	22.0	21.0	23.0	25.0	29.0
Median	17.0	20.0	18.5	25.0	22.5	27.0	27.0	31.0
SD	0.9	1.9	2.7	33.3	516.9	132.0	0.8	20.9

	221 3stories of new 3-story Apt Bldg				222 2nd story room in hotel			
	Baseline 13:30 start, 4/28; Open doors/windows		*Followup* 13:45 start, 6/2; Open doors/windows		*Baseline* 9:15 start, 4/17; Open doors/windows; Potential Source: SMK		*Followup*	
	Unit #1	*Unit #2*	*Unit #1*	*Unit #2*	*Unit #1*	*Unit #2*	*Unit #1*	*Unit #2*
Minutes	24	24	13	24	No data	31	No data	No data
Average	36.8	36.9	36.2	36.9		360.3		
Max	44.0	44.0	42.0	44.0		659.0		
Min	33.0	35.0	35.0	35.0		95.0		
Median	36.0	36.5	36.0	36.5		234.0		
SD	2.6	1.9	1.8	1.9		228.2		

	223 Back room of 1-story barbershop				224 1 story single family house (large)			
	Baseline 17:00 start, 5/1; Open doors/windows		*Followup* 16:30 start, 6/17; Open doors/windows		*Baseline* 18:00 start, 4/21; Open doors/windows; Potential Source: CK		*Followup* 16:45 start, 6/11; Open doors/windows	
	Unit #1	*Unit #2*	*Unit #1*	*Unit #2*	*Unit #1*	*Unit #2*	*Unit #1*	*Unit #2*
Minutes	33	38	20	19	36	35	20	19
Average	19.8	24.7	35.4	38.2	28.5	30.8	33.5	37.7
Max	22.0	30.0	37.0	41.0	34.0	36.0	35.0	43.0
Min	17.0	22.0	34.0	36.0	24.0	27.0	32.0	36.0
Median	20.0	24.5	35.0	38.0	29.0	30.0	34.0	37.0
SD	0.9	1.6	0.9	1.2	2.6	2.2	1.0	1.6

	225 2nd floor unit in 3 story Apt Bldg				226 1 story wood building on multi-BLDG lot			
	Baseline 11:15 start, 5/12 Open doors/windows Potential Source: SMK		*Followup* 11:15 start, 6/5 Open doors/windows		*Baseline* 12:30 start, 5/2 Open doors/windows		*Followup* 13:15 start, 6/30 Open doors/windows	
	Unit #1	*Unit #2*	*Unit #1*	*Unit #2*	*Unit #1*	*Unit #2*	*Unit #1*	*Unit #2*
Minutes	36	32	20	21	34	31	17	15
Average	51.0	48.5	22.7	26.2	31.9	47.9	36.4	43.7
Max	150.0	60.0	27.0	33.0	55.0	78.0	39.0	67.0
Min	40.0	42.0	20.0	24.0	21.0	32.0	34.0	37.0
Median	50.0	48.0	23.0	25.0	30.5	45.0	37.0	39.0
SD	18.0	5.2	1.4	2.4	9.8	12.4	1.5	9.5

	227 3stories of new 3-story Apt Bldg				228 trailer			
	Baseline 14:15 start, 4/28 Open doors/windows		*Followup* 14:32 start, 4/28 Open doors/windows		*Baseline* 19:15 start, 4/21 Open doors/windows		*Followup*	
	Unit #1	*Unit #2*	*Unit #1*	*Unit #2*	*Unit #1*	*Unit #2*	*Unit #1*	*Unit #2*
Minutes	37	32	No data	13	50	50	No data	No data
Average	19.4	23.2		31.5	17.6	28.9		
Max	23.0	29.0		46.0	22.0	39.0		
Min	18.0	22.0		29.0	16.0	23.0		
Median	19.0	23.0		30.0	17.5	29.0		
SD	0.9	1.4		4.4	1.2	4.2		

	300 2nd floor unit in 3 story Apt Bldg				301 1st floor unit in 2 story Apt Bldg			
	Baseline 16:00 start, 5/5 Open doors/windows		*Followup* 12:20 start, 6/5 Open doors/windows Potential Source: CLN		*Baseline* 14:45 start, 5/5 Open doors/windows Potential Source: CK		*Followup* 10:20 start, 6/30 Open doors/windows	
	Unit #1	*Unit #2*	*Unit #1*	*Unit #2*	*Unit #1*	*Unit #2*	*Unit #1*	*Unit #2*
Minutes	52	50	23	23	39	40	21	20
Average	19.0	25.7	29.2	32.0	151.8	260.6	33.2	37.3
Max	27.0	35.0	45.0	42.0	253.0	503.0	34.0	42.0
Min	17.0	23.0	19.0	26.0	88.0	119.0	32.0	35.0
Median	19.0	25.0	30.0	31.0	127.0	228.0	33.0	37.0
SD	1.5	2.6	7.1	5.0	51.0	117.2	0.7	1.5

	302 1st floor in 1-story duplex				303 3stories of new 3-story Apt Bldg			
	Baseline 13:00 start, 5/5 Open doors/windows		*Followup* 10:00 start, 6/5 Open doors/windows Potential Source: CK		*Baseline* 10:15 start, 5/5 Open doors/windows Potential Source: CK		*Followup* 16:15 start, 6/11 Open doors/windows	
	Unit #1	*Unit #2*	*Unit #1*	*Unit #2*	*Unit #1*	*Unit #2*	*Unit #1*	*Unit #2*
Minutes	43	41	22	22	43	43	21	20
Average	15.2	25.1	17.9	23.9	20.6	25.3	42.1	35.8
Max	17.0	68.0	19.0	25.0	35.0	30.0	50.0	37.0
Min	14.0	19.0	16.0	22.0	17.0	24.0	40.0	34.0
Median	15.0	22.0	18.0	24.0	20.0	25.0	42.0	36.0
SD	0.8	8.2	1.0	1.0	3.0	1.5	2.3	0.7

	304 1-story single family home				305 2nd story of 3-story Apt Bldg			
	Baseline 12:00 start, 5/12 Open doors/windows		*Followup* 17:00 start, 6/17 Open doors/windows & AC Potential Source: HACT		*Baseline* 17:30 start, 5/6 Open doors/windows		*Followup* 16:00 start, 6:10 Open doors/windows Potential Source: CLN	
	Unit #1	*Unit #2*	*Unit #1*	*Unit #2*	*Unit #1*	*Unit #2*	*Unit #1*	*Unit #2*
Minutes	35	32	23	22	54	52	23	22
Average	23.8	24.8	34.8	36.5	18.8	23.2	27.7	33.8
Max	40.0	31.0	47.0	43.0	26.0	61.0	31.0	54.0
Min	18.0	23.0	30.0	34.0	17.0	19.0	24.0	29.0
Median	22.0	24.5	34.0	36.0	19.0	21.0	29.0	33.5
SD	5.0	1.6	4.6	2.2	2.0	7.9	2.2	5.1

	306 2nd story of 3-story Apt Bldg				307 2nd story of 3-story Apt Bldg water heater indoors			
	Baseline 13:30 start, 5/12 Open doors/windows Potential Source: CK		*Followup* 18:40 start, 6/30 Open doors/windows		*Baseline* 16:15 start, 5/15 Open doors/windows Potential Source: CK, WH		*Followup* 16:00 start, 6/19 Open doors/windows Potential Source: CK, WH	
	Unit #1	*Unit #2*	*Unit #1*	*Unit #2*	*Unit #1*	*Unit #2*	*Unit #1*	*Unit #2*
Minutes	25	24	18	16	51	51	20	16
Average	22.3	34.7	11.6	19.6	19.1	26.0	28.5	37.0
Max	32.0	50.0	16.0	28.0	27.0	44.0	32.0	40.0
Min	16.0	25.0	10.0	16.0	17.0	22.0	25.0	34.0
Median	21.0	33.5	11.0	19.0	19.0	25.0	28.0	37.5
SD	4.0	7.0	1.6	3.1	1.8	4.0	2.2	1.8

	308 1st floor in 1-story duplex				309 1st floor in 1-story duplex			
	Baseline 11:30 start, 5/13 Open doors/windows Potential Source: CK, HACT		*Followup* 13:30 start, 6/19 Open doors/windows Potential Source: CK		*Baseline* 13:15 start, 5/13 Open doors/windows		*Followup* 12:00 start, 6/10 Open doors/windows Potential Source: CK	
	Unit #1	*Unit #2*	*Unit #1*	*Unit #2*	*Unit #1*	*Unit #2*	*Unit #1*	*Unit #2*
Minutes	39	40	18	17	47	44	24	23
Average	42.1	51.6	52.9	54.5	28.5	33.5	31.0	37.0
Max	50.0	74.0	56.0	62.0	42.0	42.0	44.0	46.0
Min	35.0	40.0	51.0	52.0	25.0	30.0	26.0	31.0
Median	43.0	49.0	53.0	54.0	27.0	33.0	31.5	38.0
SD	4.3	9.2	1.4	2.5	3.8	2.1	4.4	4.0

	310 1st floor in 1 bldg on multihouse				311 1st floor unit in 3 story Apt Bldg			
	Baseline 16:00 start, 5/15 Open doors/windows		*Followup* 16:00 start, 6/19 Open doors/windows		*Baseline* 13:15 start, 5/15 Open doors/windows		*Followup* 13:00 start, 6/19 Open doors/windows	
	Unit #1	*Unit #2*	*Unit #1*	*Unit #2*	*Unit #1*	*Unit #2*	*Unit #1*	*Unit #2*
Minutes	44	41	21	20	46	44	18	16
Average	16.2	20.0	37.7	33.3	24.3	22.5	54.6	47.4
Max	20.0	35.0	43.0	37.0	36.0	25.0	66.0	56.0
Min	14.0	18.0	34.0	31.0	22.0	21.0	51.0	44.0
Median	16.0	19.0	36.0	33.0	23.0	22.0	54.0	47.0
SD	1.3	3.3	2.9	1.7	2.7	1.0	3.1	3.7

	312 3stories of new 3-story Apt Bldg				313 3nd story of 3-story Apt Bldg			
	Baseline 19:15 start, 5/21 Closed doors/windows		*Followup* 13:30 start, 6/30 Open doors/windows		*Baseline* 1:15 start, 5/20 Open doors/windows Potential Source: WH		*Followup* 3:30 start, 6/24 Open doors/windows Potential Source: WH	
	Unit #1	*Unit #2*	*Unit #1*	*Unit #2*	*Unit #1*	*Unit #2*	*Unit #1*	*Unit #2*
Minutes	42	43	14	16	40	38	23	24
Average	21.1	29.3	31.0	36.7	23.3	27.7	34.8	41.4
Max	25.0	43.0	33.0	49.0	28.0	32.0	39.0	54.0
Min	19.0	24.0	29.0	33.0	20.0	23.0	32.0	37.0
Median	21.0	28.0	31.0	36.0	23.0	28.0	34.0	39.5
SD	1.7	4.3	1.0	3.6	1.9	2.7	2.2	4.7

	314 2nd story of 2-story Apt Bldg				315 3rd story of 3-story Apt Bldg			
	Baseline		*Followup*		*Baseline*		*Followup*	
	Unit # 1	*Unit # 2*	*Unit # 1*	*Unit # 2*	*Unit # 1*	*Unit # 2*	*Unit # 1*	*Unit # 2*
	14:43 start, 5/27 Open doors/windows		14:30 start, 6/24 Open doors/windows Potential Source: FAN		15:00 start, 5/15 Open doors/windows Potential Source: WH, HACT		12:00 start, 6/24 Open doors/windows P. Source: CK, HACT, WH	
Minutes	36	34	19	19	39	37	15	
Average	6.6	10.8	33.2	36.2	18.3	27.5	41.7	44
Max	13.0	14.0	35.0	41.0	21.0	139.0	66.0	58
Min	5.0	10.0	32.0	33.0	16.0	20.0	35.0	39
Median	6.0	11.0	33.0	36.0	18.0	23.0	39.0	43
SD	1.6	0.9	0.8	2.6	1.6	19.5	8.7	4

	316 3rd story of 3-story Apt Bldg				317 1st story of 2-story Apt Bldg			
	Baseline		*Followup*		*Baseline*		*Followup*	
	Unit # 1	*Unit # 2*	*Unit # 1*	*Unit # 2*	*Unit # 1*	*Unit # 2*	*Unit # 1*	*Unit # 2*
	13:20 start, 5/27 Open doors/windows Potential Source: WH		12:30 start, 6/24 Open doors/windows Potential Source: FAN, WH		15:30 start, 5/27 Open doors/windows		14:15 start, 6/24 Open doors/windows Potential Source: CK	
Minutes	38	39	17	17	37	36	25	
Average	6.9	12.2	32.9	38.4	10.0	19.5	34.7	44
Max	8.0	14.0	34.0	40.0	17.0	51.0	44.0	111
Min	6.0	11.0	32.0	37.0	7.0	14.0	33.0	38
Median	7.0	12.0	33.0	38.0	9.0	16.0	34.0	41
SD	0.7	0.8	0.7	0.9	2.1	8.5	2.2	14

	318 1st floor in 1-story duplex				319 3stories of new 3-story Apt Bldg			
	Baseline		*Followup*		*Baseline*		*Followup*	
	Unit # 1	*Unit # 2*	*Unit # 1*	*Unit # 2*	*Unit # 1*	*Unit # 2*	*Unit # 1*	*Unit # 2*
	18:00 start, 5/27 Open doors/windows		15:30 start, 6/30 Open doors/windows		13:30 start, 6/5 Open doors/windows		12:15 start, 6/30 Open doors/windows	
Minutes	33	33	19	18	39	38	14	
Average	8.2	16.1	16.7	20.0	19.7	25.0	29.9	33
Max	14.0	28.0	19.0	22.0	27.0	28.0	31.0	35
Min	6.0	13.0	14.0	17.0	18.0	23.0	28.0	32
Median	8.0	15.0	17.0	20.0	19.0	25.0	30.0	34
SD	1.8	3.8	1.1	1.3	1.5	1.2	0.9	0

	320 3stories of new 3-story Apt Bldg				321 2nd floor of 2-story Apt Bldg			
	Baseline		*Followup*		*Baseline*		*Followup*	
	Unit #1 11:45 start, Open doors/windows	*Unit #2*	*Unit #1* 16:00 start, 6/30 Open doors/windows	*Unit #2*	*Unit #1* 14:30 start, 6/5 Open doors/windows	*Unit #2*	*Unit #1* 17:30 start, 6/30 Open doors/windows	*Unit #2*
Minutes	33	33	19	18	34	33	34	33
Average	14.5	25.7	23.8	30.0	22.4	28.6	11.8	14.6
Max	22.0	43.0	34.0	95.0	29.0	32.0	14.0	17.0
Min	10.0	21.0	17.0	18.0	19.0	26.0	11.0	13.0
Median	14.0	24.0	22.0	24.0	21.0	28.0	11.5	14.0
SD	2.6	4.8	4.7	18.8	2.6	1.7	0.9	1.2

	322 2nd floor of 2-story Apt Bldg			
	Baseline		*Followup*	
	Unit #1 13:45 start, 6/10 Open doors/windows	*Unit #2*	*Unit #1* 11:00 start, 6/30 Open doors/windows	*Unit #2*
Minutes	56	56	15	14
Average	31.2	35.5	32.4	35.9
Max	41.0	46.0	34.0	38.0
Min	24.0	29.0	31.0	35.0
Median	30.5	33.5	32.0	36.0
SD	5.4	5.0	1.0	1.0

NOTE: “Open doors/windows” indicates at least one was open/cracked, “Closed doors/windows” indicates all were closed during monitoring, CK=visible or recent stove or microwave cooking, CLN=smell of cleaning or cosmetic products, FAN= active ceiling, window or floor fan, HACT=human activity including walking/playing near instrument or recent construction in/near unit, SMK=smell of recent smoking, TRP=traffic proximity (approximate), WH=indoor water heater